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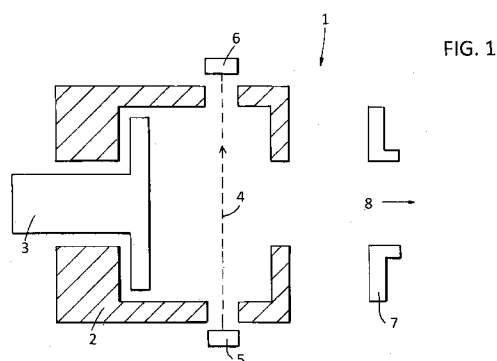
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(54) Title: SURFACE COATING ON ION SOURCE



(57) Abstract: An ion source is disclosed comprising a Diamond Like Carbon surface.

SURFACE COATING ON ION SOURCE

This application claims priority to and benefit of U.S. Provisional Patent Application
5 Serial No. US 61/181,418 filed on 27 May 2009 and United Kingdom Patent Application
No. 0908247.0 filed on 13 May 2009. The entire contents of these applications are
incorporated herein by reference.

BACKGROUND OF THE INVENTION

10 The present invention relates to an ion source having a surface coating or layer.

Mass spectrometers comprising a gas chromatograph coupled to an Electron
Ionisation ("EI") or Chemical Ionisation ("CI") ion source are well known. A gas
chromatograph comprises a packed column or open capillary tube located in a heated
15 chamber. Analyte gas molecules are caused to pass through the column. Gas molecules
having different sizes and structures will take different amounts of time to elute from the
gas chromatograph.

Ions which emerge from the gas chromatograph are then commonly ionised either
by an Electron Ionisation ion source or by a Chemical Ionisation ion source.

20 An EI ion source comprises an ion chamber through which an electron beam is
passed. Analyte gas molecules interact with the electron beam and are subsequently
ionised. The ionisation process is commonly referred to as being a hard ionisation process
in that the analyte molecules are caused to fragment as a result of the ionisation process.
The resulting EI fragment ions are then mass analysed.

25 A CI ion source utilises a reagent gas (e.g. methane or ammonia) and may be
operated in either a positive or negative mode of operation. Neutral reagent gas is
arranged to be ionised by interactions with free electrons emitted from a filament. The
resulting reagent ions are then caused to interact and ionise neutral analyte molecules
resulting in the formation of analyte ions. The resulting analyte ions are then mass
30 analysed.

The coupling of a gas chromatography column with an EI or CI ion source and a
mass spectrometer is a powerful technique that is widely used in many laboratories.

Conventionally, EI and CI ion sources comprise ion source chambers made
from stainless steel. Stainless steel is considered to be relatively inert and non-
35 reactive. However, conventional EI and CI ion source chambers need regular
cleaning in order to maintain high performance.

Conventional EI and CI ion source chambers can suffer from increased
surface contamination following regular analysis of complex matrix extracts such as
urine, saliva, plasma, whole blood, waters and soils.

SUMMARY OF THE INVENTION

According to an aspect of the present invention there is provided a mass spectrometer comprising an ion source, wherein the ion source comprises a first coating or surface provided on at least a portion of the ion source, wherein the first coating or surface comprises a ceramic coating or surface or a Diamond Like Carbon ("DLC") coating or surface.

A Diamond Like Carbon ("DLC") coating is an amorphous carbon coating and differs therefore from diamond coatings which are polycrystalline. A DLC coating is conductive which is particularly advantageous compared with diamond coatings which are insulating and non-conductive.

A DLC coating also has a low coefficient of friction and is therefore highly non-stick. DLC coatings are also particularly robust and have a high hardness and have a high temperature resistance. The DLC coating is therefore particularly advantageous compared with graphite which will tend to oxidise at high temperatures.

The ion source preferably comprises one or more ionisation chambers and the first coating or surface is preferably provided on at least a portion of the one or more ionisation chambers.

The ion source preferably further comprises one or more repeller electrodes and the first coating or surface is preferably provided on at least a portion of the one or more repeller electrodes.

The ion source and/or the one or more ionisation chambers and/or the one or more repeller electrodes forming part of the ion source are preferably made from a material selected from the group consisting of: (i) stainless steel; (ii) a steel alloy comprising $\geq$ 11.5% chromium wt.%; (iii) an austenitic stainless steel; (iv) a ferritic stainless steel; (v) an austenitic-ferritic or duplex steel; (vi) titanium; (vii) a titanium alloy; (viii) a nickel-base alloy; (ix) a nickel-chromium alloy; (x) a nickel-chromium alloy comprising $\geq$ 50.0% nickel wt.%; and (xi) INCONEL (RTM) 600, 625, 690, 702, 718, 939 or X750.

The ion source and/or the one or more ionisation chambers and/or the one or more repeller electrodes forming part of the ion source preferably comprise stainless steel or an alloy comprising: (i) 0-0.01 wt.% carbon; (ii) 0.01-0.02 wt.% carbon; (iii) 0.02-0.03 wt.% carbon; (iv) 0.03-0.04 wt.% carbon; (v) 0.04-0.05 wt.% carbon; (vi) 0.05-0.06 wt.% carbon; (vii) 0.06-0.07 wt.% carbon; (viii) 0.07-0.08 wt.% carbon; and (ix) $>$ 0.08 wt.% carbon.

The ion source and/or the one or more ionisation chambers and/or the one or more repeller electrodes forming part of the ion source preferably comprise stainless steel or an alloy comprising: (i) 0-0.01 wt.% nitrogen; (ii) 0.01-0.02 wt.% nitrogen; (iii) 0.02-0.03 wt.% nitrogen; (iv) 0.03-0.04 wt.% nitrogen; (v) 0.04-0.05 wt.% nitrogen; (vi) 0.05-0.06 wt.% nitrogen; (vii) 0.06-0.07 wt.% nitrogen; and (viii) $>$ 0.07 wt.% nitrogen.

The ion source and/or the one or more ionisation chambers and/or the one or more repeller electrodes forming part of the ion source preferably comprise stainless steel or an alloy comprising: (i) 0-0.1 wt.% nitrogen; (ii) 0.1-0.2 wt.% nitrogen; (iii) 0.2-0.3 wt.%

nitrogen; (iv) 0.3-0.4 wt.% nitrogen; (v) 0.4-0.5 wt.% nitrogen; (vi) 0.5-0.6 wt.% nitrogen; (vii) 0.6-0.7 wt.% nitrogen; and (viii) > 0.7 wt.% nitrogen.

The ion source and/or the one or more ionisation chambers and/or the one or more repeller electrodes forming part of the ion source preferably comprise stainless steel or an alloy comprising: (i) 12.0-13.0 wt.% chromium; (ii) 13.0-14.0 wt.% chromium; (iii) 14.0-15.0 wt.% chromium; (iv) 15.0-16.0 wt.% chromium; (v) 16.0-17.0 wt.% chromium; (vi) 17.0-18.0 wt.% chromium; (vii) 18.0-19.0 wt.% chromium; (viii) 19.0-20.0 wt.% chromium; (ix) 20.0-21.0 wt.% chromium; (x) 21.0-22.0 wt.% chromium; (xi) 22.0-23.0 wt.% chromium; (xii) 23.0-24.0 wt.% chromium; (xiii) 24.0-25.0 wt.% chromium; (xiv) 25.0-26.0 wt.% chromium; (xv) 26.0-27.0 wt.% chromium; (xvi) 27.0-28.0 wt.% chromium; (xvii) 28.0-29.0 wt.% chromium; (xviii) 29.0-30.0 wt.% chromium; and (xix) > 30.0 wt.% chromium.

The ion source and/or the one or more ionisation chambers and/or the one or more repeller electrodes forming part of the ion source preferably comprise stainless steel or an alloy comprising: (i) 0-1.0 wt.% nickel; (ii) 1.0-2.0 wt.% nickel; (iii) 2.0-3.0 wt.% nickel; (iv) 3.0-4.0 wt.% nickel; (v) 4.0-5.0 wt.% nickel; (vi) 5.0-6.0 wt.% nickel; (vii) 6.0-7.0 wt.% nickel; (viii) 7.0-8.0 wt.% nickel; (ix) 8.0-9.0 wt.% nickel; (x) 9.0-10.0 wt.% nickel; (xi) 10.0-11.0 wt.% nickel; (xii) 11.0-12.0 wt.% nickel; (xiii) 12.0-13.0 wt.% nickel; (xiv) 13.0-14.0 wt.% nickel; (xv) 14.0-15.0 wt.% nickel; (xvi) 15.0-16.0 wt.% nickel; (xvii) 16.0-17.0 wt.% nickel; (xviii) 17.0-18.0 wt.% nickel; (xix) 18.0-19.0 wt.% nickel; (xx) 19.0-20.0 wt.% nickel; (xxi) 20.0-21.0 wt.% nickel; (xxii) 21.0-22.0 wt.% nickel; (xxiii) 22.0-23.0 wt.% nickel; (xxiv) 23.0-24.0 wt.% nickel; (xxv) 24.0-25.0 wt.% nickel; (xxvi) 25.0-26.0 wt.% nickel; (xxvii) 26.0-27.0 wt.% nickel; (xxviii) 27.0-28.0 wt.% nickel; (xxix) 28.0-29.0 wt.% nickel; (xxx) 29.0-30.0 wt.% nickel; (xxxi) 30.0-31.0 wt.% nickel; (xxxii) 31.0-32.0 wt.% nickel; (xxxiii) 32.0-33.0 wt.% nickel; (xxxiv) 33.0-34.0 wt.% nickel; (xxxv) 34.0-35.0 wt.% nickel; (xxxvi) 35.0-36.0 wt.% nickel; (xxxvii) 36.0-37.0 wt.% nickel; (xxxviii) 37.0-38.0 wt.% nickel; (xxxix) 38.0-39.0 wt.% nickel; (xl) 39.0-40.0 wt.% nickel; (xli) 40.0-41.0 wt.% nickel; (xlii) 41.0-42.0 wt.% nickel; (xliii) 42.0-43.0 wt.% nickel; (xliv) 43.0-44.0 wt.% nickel; (xlv) 44.0-45.0 wt.% nickel; (xlvi) 45.0-46.0 wt.% nickel; (xlvii) > 46.0 wt.% nickel.

The ion source and/or the one or more ionisation chambers and/or the one or more repeller electrodes forming part of the ion source preferably comprise stainless steel or an alloy comprising: (i) 0-1.0 wt.% molybdenum; (ii) 1.0-2.0 wt.% molybdenum; (iii) 2.0-3.0 wt.% molybdenum; (iv) 3.0-4.0 wt.% molybdenum; (v) 4.0-5.0 wt.% molybdenum; (vi) 5.0-6.0 wt.% molybdenum; (vii) 6.0-7.0 wt.% molybdenum; (viii) 7.0-8.0 wt.% molybdenum; and (ix) > 8.0 wt.% molybdenum.

The ion source and/or the one or more ionisation chambers and/or the one or more repeller electrodes forming part of the ion source preferably comprise stainless steel or an alloy comprising: (i) 0-1.0 wt.% copper; (ii) 1.0-2.0 wt.% copper; (iii) 2.0-3.0 wt.% copper; (iv) 3.0-4.0 wt.% copper; and (v) > 4.0 wt.% copper.

The ion source and/or the one or more ionisation chambers and/or the one or more repeller electrodes forming part of the ion source preferably comprise stainless steel or an alloy comprising: (i) 0.01-1.0 wt.% X; (ii) 1.0-2.0 wt.% X; (iii) 2.0-3.0 wt.% X; (iv) 3.0-4.0 wt.% X; and (v) > 4.0 wt.% X; wherein X comprises cobalt and/or tantalum and/or

aluminium and/or titanium and/or niobium and/or silicon and/or manganese and/or tungsten and/or phosphorous.

The first coating or surface is preferably provided on: (i) at least 5%, 10%, 15%, 20%, 25%, 30%, 35%, 40%, 45%, 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95% or 100% of an inner surface and/or an outer surface of the ion source; and/or (ii) at least 5%, 10%, 15%, 20%, 25%, 30%, 35%, 40%, 45%, 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95% or 100% of an inner surface and/or an outer surface of the one or more ionisation chambers; and/or (iii) at least 5%, 10%, 15%, 20%, 25%, 30%, 35%, 40%, 45%, 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95% or 100% of an inner surface and/or an outer surface of the one or more repeller electrodes.

The Diamond Like Carbon coating preferably comprises a SP2 (graphite) to SP3 (diamond) ratio selected from the group consisting of: (i) < 0.1; (ii) 0.1-0.2; (iii) 0.2-0.3; (iv) 0.3-0.4; (v) 0.4-0.5; (vi) 0.5-0.6; (vii) 0.6-0.7; (viii) 0.7-0.8; (ix) 0.8-0.9; and (x) 0.9-1.0.

The Diamond Like Carbon coating or surface preferably comprises a carbon coating or surface having a diamond-like structure.

The Diamond Like Carbon coating or surface preferably further comprises a metal component such as chromium.

The ceramic coating or surface preferably comprises silicon carbide or SiC.

The first coating or surface preferably has either:

(a) a resistivity selected from the group consisting of: (i) < 10^{-3} Ω -m; (ii) < 10^{-4} Ω -m; (iii) < 10^{-5} Ω -m; (iv) < 10^{-6} Ω -m; (v) < 10^{-7} Ω -m; (vi) 10^{-3} - 10^{-4} Ω -m; (vii) 10^{-4} - 10^{-5} Ω -m; (viii) 10^{-5} - 10^{-6} Ω -m; and (ix) 10^{-6} - 10^{-7} Ω -m; and/or

(b) a Vickers hardness number or Vickers Pyramid Number (HV) selected from the group consisting of: (i) > 1000; (ii) 1000-1100; (iii) 1100-1200; (iv) 1200-1300; (v) 1300-1400; (vi) 1400-1500; (vii) 1500-1600; (viii) 1600-1700; (ix) 1700-1800; (x) 1800-1900; (xi) 1900-2000; (xii) 2000-2100; (xiii) 2100-2200; (xiv) 2200-2300; (xv) 2300-2400; (xvi) 2400-2500; (xvii) 2500-2600; (xviii) 2600-2700; (xix) 2700-2800; (xx) 2800-2900; (xxi) 2900-3000; (xxii) 3000-3100; (xxiii) 3100-3200; (xxiv) 3200-3300; (xv) 3300-3400; (xvi) 3400-3500; and (xvii) > 3500, wherein the Vickers hardness number or Vickers Pyramid Number is determined at a load of 30, 40, 50, 60 or 70 kg; and/or

(c) a Vickers microhardness selected from the group consisting of: (i) > 1000 kg/mm; (ii) 1000-1100 kg/mm; (iii) 1100-1200 kg/mm; (iv) 1200-1300 kg/mm; (v) 1300-1400 kg/mm; (vi) 1400-1500 kg/mm; (vii) 1500-1600 kg/mm; (viii) 1600-1700 kg/mm; (ix) 1700-1800 kg/mm; (x) 1800-1900 kg/mm; (xi) 1900-2000 kg/mm; (xii) 2000-2100 kg/mm; (xiii) 2100-2200 kg/mm; (xiv) 2200-2300 kg/mm; (xv) 2300-2400 kg/mm; (xvi) 2400-2500 kg/mm; (xvii) 2500-2600 kg/mm; (xviii) 2600-2700 kg/mm; (xix) 2700-2800 kg/mm; (xx) 2800-2900 kg/mm; (xxi) 2900-3000 kg/mm; (xxii) 3000-3100 kg/mm; (xxiii) 3100-3200 kg/mm; (xxiv) 3200-3300 kg/mm; (xv) 3300-3400 kg/mm; (xvi) 3400-3500 kg/mm; and (xvii) > 3500 kg/mm, and/or

(d) a thickness selected from the group consisting of: (i) < 1 μ m; (ii) 1-2 μ m; (iii) 2-3 μ m; (iv) 3-4 μ m; (v) 4-5 μ m; (vi) 5-6 μ m; (vii) 6-7 μ m; (viii) 7-8 μ m; (ix) 8-9 μ m; (x) 9-10 μ m; (xi) > 10 μ m; and/or

(e) a density selected from the group consisting of: (i) $< 3.0 \text{ g cm}^{-3}$; (ii) $3.0\text{-}3.5 \text{ g cm}^{-3}$; (iii) $3.5\text{-}4.0 \text{ g cm}^{-3}$; (iv) $4.0\text{-}4.5 \text{ g cm}^{-3}$; (v) $4.5\text{-}5.0 \text{ g cm}^{-3}$; (vi) $5.0\text{-}5.5 \text{ g cm}^{-3}$; (vii) $5.5\text{-}6.0 \text{ g cm}^{-3}$; (viii) $6.0\text{-}6.5 \text{ g cm}^{-3}$; (ix) $6.5\text{-}7.0 \text{ g cm}^{-3}$; (x) $7.0\text{-}7.5 \text{ g cm}^{-3}$; (xi) $7.5\text{-}8.0 \text{ g cm}^{-3}$; (xii) $8.0\text{-}8.5 \text{ g cm}^{-3}$; (xiii) $8.5\text{-}9.0 \text{ g cm}^{-3}$; (xiv) $9.0\text{-}9.5 \text{ g cm}^{-3}$; (xv) $9.5\text{-}10.0 \text{ g cm}^{-3}$; (xvi) $10.0\text{-}10.5 \text{ g cm}^{-3}$; (xvii) $10.5\text{-}11.0 \text{ g cm}^{-3}$; (xviii) $11.0\text{-}11.5 \text{ g cm}^{-3}$; (xix) $11.5\text{-}12.0 \text{ g cm}^{-3}$; (xx) $12.0\text{-}12.5 \text{ g cm}^{-3}$; (xxi) $12.5\text{-}13.0 \text{ g cm}^{-3}$; (xxii) $13.0\text{-}13.5 \text{ g cm}^{-3}$; (xxiii) $13.5\text{-}14.0 \text{ g cm}^{-3}$; (xxiv) $14.0\text{-}14.5 \text{ g cm}^{-3}$; (xxv) $14.5\text{-}15.0 \text{ g cm}^{-3}$; (xxvi) $15.0\text{-}15.5 \text{ g cm}^{-3}$; (xxvii) $15.5\text{-}16.0 \text{ g cm}^{-3}$; (xxviii) $16.0\text{-}16.5 \text{ g cm}^{-3}$; (xxix) $16.5\text{-}17.0 \text{ g cm}^{-3}$; (xxx) $17.0\text{-}17.5 \text{ g cm}^{-3}$; (xxxi) $17.5\text{-}18.0 \text{ g cm}^{-3}$; (xxxii) $18.0\text{-}18.5 \text{ g cm}^{-3}$; (xxxiii) $18.5\text{-}19.0 \text{ g cm}^{-3}$; (xxxiv) $19.0\text{-}19.5 \text{ g cm}^{-3}$; (xxxv) $19.5\text{-}20.0 \text{ g cm}^{-3}$; and (xxxvi) $> 20.0 \text{ g cm}^{-3}$; and/or

(f) a coefficient of friction selected from the group consisting of: (i) < 0.01 ; (ii) $0.01\text{-}0.02$; (iii) $0.02\text{-}0.03$; (iv) $0.03\text{-}0.04$; (v) $0.04\text{-}0.05$; (vi) $0.05\text{-}0.06$; (vii) $0.06\text{-}0.07$; (viii) $0.07\text{-}0.08$; (ix) $0.08\text{-}0.09$; (x) $0.09\text{-}0.10$; and (xi) > 0.1 .

The portion of the ion source having the first coating or surface is preferably selected from the group consisting of: (i) an ion chamber; (ii) a repeller electrode; and (iii) an exit plate or exit aperture arranged at the exit of the ion source through which ions of interest are desired to be transmitted.

The ion source is preferably selected from the group consisting of: (i) an Electrospray ionisation ("ESI") ion source; (ii) an Atmospheric Pressure Photo Ionisation ("APPI") ion source; (iii) an Atmospheric Pressure Chemical Ionisation ("APCI") ion source; (iv) a Matrix Assisted Laser Desorption Ionisation ("MALDI") ion source; (v) a Laser Desorption Ionisation ("LDI") ion source; (vi) an Atmospheric Pressure Ionisation ("API") ion source; (vii) a Desorption Ionisation on Silicon ("DIOS") ion source; (viii) an Electron Impact ("EI") ion source; (ix) a Chemical Ionisation ("CI") ion source; (x) a Field Ionisation ("FI") ion source; (xi) a Field Desorption ("FD") ion source; (xii) an Inductively Coupled Plasma ("ICP") ion source; (xiii) a Fast Atom Bombardment ("FAB") ion source; (xiv) a Liquid Secondary Ion Mass Spectrometry ("LSIMS") ion source; (xv) a Desorption Electrospray Ionisation ("DESI") ion source; (xvi) a Nickel-63 radioactive ion source; (xvii) an Atmospheric Pressure Matrix Assisted Laser Desorption Ionisation ion source; (xviii) a Thermospray ion source; (xix) an Atmospheric Sampling Glow Discharge Ionisation ("ASGDI") ion source; and (xx) a Glow Discharge ("GD") ion source.

According to an aspect of the present invention there is provided a method of mass spectrometry comprising:

ionising ions in an ion source having a first coating or surface provided on at least a portion of the ion source, wherein the first coating or surface comprises a ceramic coating or surface or a Diamond Like Carbon ("DLC") coating or surface.

According to an aspect of the present invention there is provided a method of making an ion source and/or one or more ionisation chambers and/or one or more repeller electrodes forming part of an ion source for a mass spectrometer comprising:

depositing, sputtering or forming a first coating or surface on at least a portion of an ion source and/or one or more ionisation chambers and/or one or more repeller electrodes

forming part of the ion source, wherein the first coating or surface comprises a ceramic coating or surface or a Diamond Like Carbon ("DLC") coating or surface.

The step of depositing, sputtering or forming the first coating or surface preferably comprises using a method selected from the group consisting of: (i) magnetron sputtering; (ii) closed field unbalanced magnetron sputter ion plating; (iii) electroplating; (iv) thermal spray coating; (v) vapour deposition; (vi) Chemical Vapour Deposition ("CVD"); (vii) combustion torch/flame spraying; (viii) electric arc spraying; (ix) plasma spraying; (x) ion plating; (xi) ion implantation; (xii) sputtering; (xiii) sputter deposition; (xiv) laser surface alloying; (xv) Physical Vapour Deposition ("PVD"); (xvi) plasma-based ion plating; (xvii) gas plasma discharge sputtering; (xviii) laser cladding; (xix) plasma enhanced Chemical Vapour Deposition; (xx) low pressure Chemical Vapour Deposition; (xxi) laser enhanced Chemical Vapour Deposition; (xxii) active reactive evaporation; (xxiii) Pulsed Laser Deposition ("PLD"); (xxiv) RF-sputtering; (xxv) Ion-Beam Sputtering ("IBS"); (xxvi) reactive sputtering; (xxvii) Ion-Assisted Deposition ("IAD"); (xxviii) high target utilisation sputtering; (xxix) High Power Impulse Magnetron Sputtering ("HIPIMS"); and (xxx) DC-sputtering.

The step of depositing, sputtering or forming the first coating or surface preferably comprises creating a glow or RF discharge to the ion source and/or the one or more ionisation chambers and/or the one or more repeller electrodes forming part of the ion source in an atmosphere containing a hydrocarbon gas, wherein the glow or RF discharge causes a breakdown of the hydrocarbon gas so that carbon from the gas is deposited on the ion source and/or the one or more ionisation chambers and/or the one or more repeller electrodes forming part of the ion source.

The step of depositing, sputtering or forming the first coating or surface preferably comprises applying a pulsed DC biased power supply to the ion source and/or the one or more ionisation chambers and/or the one or more repeller electrodes forming part of the ion source in an atmosphere containing a hydrocarbon gas, wherein the pulsed DC biased power supply causes a breakdown of the hydrocarbon gas so that carbon from the gas is deposited on the ion source and/or the one or more ionisation chambers and/or the one or more repeller electrodes forming part of the ion source.

The hydrocarbon gas preferably comprises butane.

The step of depositing, sputtering or forming the first coating or surface preferably further comprises simultaneously depositing a metal with the deposition of carbon from the hydrocarbon gas to form a Diamond Like Carbon coating or surface including a metal therein. The metal preferably comprises chromium.

The preferred embodiment relates to an EI or CI ion source wherein the ion source is provided with a surface coating. According to the preferred embodiment surface coatings and surface modification techniques are used to passivate the surfaces contained in an EI or CI source region thereby reducing the surface reactions of molecules prior to ionisation.

Chemical standards were used to investigate the effects of a surface coating. The effects on full scan sensitivity/ionisation were observed.

- 7 -

It is believed that the coated surface of the ion source according to the preferred embodiment reduces adsorption/degradation or decomposition of compounds upon contact with the surface prior to ionisation. Data has been produced to show that the chemical nature of the analyte seems to have a significant effect on the sensitivity. For example, a relatively polar compound (or one containing a polar moiety or weak bonds prone to thermal degradation) can be detected with increased sensitivity from a coated volume in comparison to a cleaned stainless steel ion source.

The preferred embodiment is particularly advantageous in that a clean conductive (or semi conductive) surface can be provided which is robust to abrasive cleaning and is inert. The surface reduces adsorption, catalysis and degradation/decomposition and hence visual residence time of the chemical within the source environment. The improved ion source also exhibits an increase in apparent sensitivity (compound dependant) and improved sample robustness/reproducibility.

The preferred embodiment is concerned with an improved inert, semi-conductive inorganic coating on an ion source surface.

According to the preferred embodiment the source volume, trap, repeller and ion exit plate of an ion source may be coated with a preferred surface material.

BRIEF DESCRIPTION OF THE DRAWINGS

Various embodiments of the present invention together with other arrangements given for illustrative purposes only will now be described, by way of example only, and with reference to the accompanying drawings in which:

Fig. 1 shows a schematic diagram of an Electron Ionisation ion source according to an embodiment of the present invention;

Fig. 2 shows a schematic diagram of an Chemical Ionisation ion source according to an embodiment of the present invention;

Fig. 3 shows the chemical structure of 2,4 dinitrophenol;

Fig. 4 shows the chemical structure of 4 amino biphenyl;

Fig. 5 shows the chemical structure of phenobarbital; and

Fig. 6 shows a comparison of the average intensities, signal-to-noise, noise amplitude and area observed for three compounds with different ion sources.

DETAILED DESCRIPTION OF THE INVENTION

Preferred embodiments of the present invention will now be described. Fig. 1 shows a schematic diagram of an Electron Ionisation ion source 1 comprising a housing 2 forming a chamber and a repeller electrode 3. A neutral analyte gas is introduced from a gas chromatograph into the ion chamber 2. An electron beam 4 is arranged to pass from a heated filament 5 to an electron collector 6. Analyte gas molecules within the ion chamber 2 are preferably caused to interact with the electron beam 4 and as a result the analyte molecules are ionised and form analyte ions. The ionisation process is commonly referred to as being a hard ionisation process in that the analyte molecules fragment during the

ionisation process. The resulting analyte fragment ions are repelled from the ion chamber 2 by the repeller electrode 3. The analyte fragment ions may according to an embodiment pass through a lens system 7 before being onwardly transmitted in the direction shown by arrow 8 to subsequent vacuum stages of a mass spectrometer.

5 Fig. 2 shows a Chemical Ionisation ion source 9 comprising an ion chamber 10 and optional ion repeller 11. A heated filament 12 serves as an electron source and may according to one embodiment be located between an optional repeller plate 13 and an electron lens 14. The electron lens 14 may comprise a plate with a rectangular slot or other shaped aperture aligned with the heated filament 12. Electrons produced by the
10 heated filament 12 are directed into the inside of the ion chamber 10 and preferably collide with neutral reagent gas molecules such as methane and ionise the reagent gas. The resulting reagent ions are then preferably caused to interact with neutral analyte molecules with the result that analyte ions are formed. Analyte ions may be repelled from the chamber 10 by an optional repeller electrode 11 or otherwise extracted from the chamber
15 10. However, according to a preferred embodiment both the repeller plate 13 and the repeller electrode 11 are omitted. The analyte ions may pass through a lens system 12 prior to being onwardly transmitted to subsequent vacuum stages of a mass spectrometer.

Source surface coatings which were applied to an Electron Ionisation ion source which was operated in an EI+ mode of operation were investigated using a mixture of semi
20 polar GC amenable compounds. The effect on full scan sensitivity was investigated using a gas chromatograph with a tandem mass spectrometer.

The EI ion source which was investigated comprised a source volume, a trap, a repeller and an ion exit plate. These components were all coated with titanium carbide in order to demonstrate the advantages of a coated system.

25 The following results relate to data which was obtained from: (i) a standard used stainless steel ion source; (ii) an ion source wherein the ion source chamber and other components were coated with titanium carbide (TiC); and (iii) a standard cleaned stainless steel ion source.

30 The ion sources were investigated using a mixture of the following compounds: 2,4 dinitrophenol, 4 amino biphenyl and phenobarbital. The structures of 2,4 dinitrophenol, 4 amino biphenyl and phenobarbital are shown in Figs. 3-5 respectively.

Fig. 6 shows the ratio increase of the averaged surface coated and cleaned stainless steel ion sources against an uncleaned stainless steel ion source surface for the three compounds. Factor response differences for signal intensity, signal to noise,
35 chemical noise amplitude and peak area are shown.

The TiC coated ion source volume exhibited a signal intensity factor increase of 3.1 for 2,4 dinitrophenol compared to the aged stainless steel ion source. Similarly, the TiC coated ion source exhibited a signal intensity factor increase of 1.6 for 4 amino biphenyl and an increase of 2.5 for phenobarbital compared to the aged stainless steel ion source.

40 The cleaned stainless steel ion source produced an immediate improvement in signal intensity compared to the aged stainless steel ion source for all the analytes by a

factor of 1.6 for 2,4 dinitrophenol, by a factor of 3.3 for 4 amino-biphenyl and by a factor of 1.3 for phenobarbital.

The signal improvements are greater for the TiC coated ion source but lower than the cleaned stainless steel ion source for 4 amino biphenyl. Of significance is the lower noise amplitude observed for the TiC coated ion source compared to the cleaned stainless steel ion source suggesting possible noise from the cleaning process.

However, the noise amplitude for both the cleaned stainless steel ion source and the TiC coated ion source was higher than the used stainless steel ion source reducing the signal-to-noise (S:N) value while the TiC surface ion source increased the signal more than the noise resulting in an much improved S:N value for all the compounds.

Additionally, the variation for three compounds under investigation of the TiC coated ion source against the cleaned stainless steel ion source are shown in Figure 7. Within the table format is included the factor response differences for the signal intensity, signal to noise ratio (RMS) chemical noise amplitude and peak area.

An improvement in signal intensity, signal to noise (due to the relative drop in noise) and area counts were observed for both 2,4 dinitrophenol and phenobarbital. These compounds are of a more polar nature and have a potential reactive moiety present on the molecule. The TiC coated ion source provided lower sensitivity in scanning sensitivity for 4-aminobiphenyl compared to the cleaned stainless steel ion source.

Although the experimental results described above were obtained using components coated with titanium carbide, initial investigations suggest that similar results occur when the components are coated with a ceramic coating or a Diamond Like Carbon coating according to the preferred embodiment of the present invention.

Although the present invention has been described with reference to the preferred embodiments, it will be understood by those skilled in the art that various changes in form and detail may be made without departing from the scope of the invention as set forth in the accompanying claims.

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Claims

- 5 1. A mass spectrometer comprising an ion source, wherein said ion source comprises a first coating or surface provided on at least a portion of said ion source, wherein said first coating or surface comprises a Diamond Like Carbon ("DLC") coating or surface.
- 10 2. A mass spectrometer as claimed in claim 1, wherein said ion source comprises one or more ionisation chambers and said first coating or surface is provided on at least a portion of said one or more ionisation chambers.
- 15 3. A mass spectrometer as claimed in claim 1 or 2, wherein said ion source further comprises one or more repeller electrodes and said first coating or surface is provided on at least a portion of said one or more repeller electrodes.
- 20 4. A mass spectrometer as claimed in claim 1, 2 or 3, wherein said ion source and/or said one or more ionisation chambers and/or said one or more repeller electrodes forming part of said ion source are made from a material selected from the group consisting of: (i) stainless steel; (ii) a steel alloy comprising $\geq 11.5\%$ chromium wt.%; (iii) an austenitic stainless steel; (iv) a ferritic stainless steel; (v) an austenitic-ferritic or duplex steel; (vi) titanium; (vii) a titanium alloy; (viii) a nickel-base alloy; (ix) a nickel-chromium alloy; (x) a nickel-chromium alloy comprising $\geq 50.0\%$ nickel wt.%; and (xi) INCONEL (RTM) 600, 625, 690, 702, 718, 939 or X750.
- 25 5. A mass spectrometer as claimed in any preceding claim, wherein said ion source and/or said one or more ionisation chambers and/or said one or more repeller electrodes forming part of said ion source comprise stainless steel or an alloy comprising:
(i) 0-0.01 wt.% carbon; (ii) 0.01-0.02 wt.% carbon; (iii) 0.02-0.03 wt.% carbon; (iv) 0.03-0.04 wt.% carbon; (v) 0.04-0.05 wt.% carbon; (vi) 0.05-0.06 wt.% carbon; (vii) 0.06-0.07 wt.% carbon; (viii) 0.07-0.08 wt.% carbon; and (ix) > 0.08 wt.% carbon.
- 30 6. A mass spectrometer as claimed in any preceding claim, wherein said ion source and/or said one or more ionisation chambers and/or said one or more repeller electrodes forming part of said ion source comprise stainless steel or an alloy comprising:
(i) 0-0.01 wt.% nitrogen; (ii) 0.01-0.02 wt.% nitrogen; (iii) 0.02-0.03 wt.% nitrogen; (iv) 0.03-0.04 wt.% nitrogen; (v) 0.04-0.05 wt.% nitrogen; (vi) 0.05-0.06 wt.% nitrogen; (vii) 0.06-0.07 wt.% nitrogen; and (viii) > 0.07 wt.% nitrogen.
- 40 7. A mass spectrometer as claimed in any preceding claim, wherein said ion source and/or said one or more ionisation chambers and/or said one or more repeller electrodes forming part of said ion source comprise stainless steel or an alloy comprising:

(i) 0-0.1 wt.% nitrogen; (ii) 0.1-0.2 wt.% nitrogen; (iii) 0.2-0.3 wt.% nitrogen; (iv) 0.3-0.4 wt.% nitrogen; (v) 0.4-0.5 wt.% nitrogen; (vi) 0.5-0.6 wt.% nitrogen; (vii) 0.6-0.7 wt.% nitrogen; and (viii) > 0.7 wt.% nitrogen.

5 8. A mass spectrometer as claimed in any preceding claim, wherein said ion source and/or said one or more ionisation chambers and/or said one or more repeller electrodes forming part of said ion source comprise stainless steel or an alloy comprising:

(i) 12.0-13.0 wt.% chromium; (ii) 13.0-14.0 wt.% chromium; (iii) 14.0-15.0 wt.% chromium; (iv) 15.0-16.0 wt.% chromium; (v) 16.0-17.0 wt.% chromium; (vi) 17.0-18.0 wt.% chromium; (vii) 18.0-19.0 wt.% chromium; (viii) 19.0-20.0 wt.% chromium; (ix) 20.0-21.0 wt.% chromium; (x) 21.0-22.0 wt.% chromium; (xi) 22.0-23.0 wt.% chromium; (xii) 23.0-24.0 wt.% chromium; (xiii) 24.0-25.0 wt.% chromium; (xiv) 25.0-26.0 wt.% chromium; (xv) 26.0-27.0 wt.% chromium; (xvi) 27.0-28.0 wt.% chromium; (xvii) 28.0-29.0 wt.% chromium; (xviii) 29.0-30.0 wt.% chromium; and (xix) > 30.0 wt.% chromium.

15 9. A mass spectrometer as claimed in any preceding claim, wherein said ion source and/or said one or more ionisation chambers and/or said one or more repeller electrodes forming part of said ion source comprise stainless steel or an alloy comprising:

(i) 0-1.0 wt.% nickel; (ii) 1.0-2.0 wt.% nickel; (iii) 2.0-3.0 wt.% nickel; (iv) 3.0-4.0 wt.% nickel; (v) 4.0-5.0 wt.% nickel; (vi) 5.0-6.0 wt.% nickel; (vii) 6.0-7.0 wt.% nickel; (viii) 7.0-8.0 wt.% nickel; (ix) 8.0-9.0 wt.% nickel; (x) 9.0-10.0 wt.% nickel; (xi) 10.0-11.0 wt.% nickel; (xii) 11.0-12.0 wt.% nickel; (xiii) 12.0-13.0 wt.% nickel; (xiv) 13.0-14.0 wt.% nickel; (xv) 14.0-15.0 wt.% nickel; (xvi) 15.0-16.0 wt.% nickel; (xvii) 16.0-17.0 wt.% nickel; (xviii) 17.0-18.0 wt.% nickel; (xix) 18.0-19.0 wt.% nickel; (xx) 19.0-20.0 wt.% nickel; (xxi) 20.0-21.0 wt.% nickel; (xxii) 21.0-22.0 wt.% nickel; (xxiii) 22.0-23.0 wt.% nickel; (xxiv) 23.0-24.0 wt.% nickel; (xxv) 24.0-25.0 wt.% nickel; (xxvi) 25.0-26.0 wt.% nickel; (xxvii) 26.0-27.0 wt.% nickel; (xxviii) 27.0-28.0 wt.% nickel; (xxix) 28.0-29.0 wt.% nickel; (xxx) 29.0-30.0 wt.% nickel; (xxxi) 30.0-31.0 wt.% nickel; (xxxii) 31.0-32.0 wt.% nickel; (xxxiii) 32.0-33.0 wt.% nickel; (xxxiv) 33.0-34.0 wt.% nickel; (xxxv) 34.0-35.0 wt.% nickel; (xxxvi) 35.0-36.0 wt.% nickel; (xxxvii) 36.0-37.0 wt.% nickel; (xxxviii) 37.0-38.0 wt.% nickel; (xxxix) 38.0-39.0 wt.% nickel; (xl) 39.0-40.0 wt.% nickel; (xli) 40.0-41.0 wt.% nickel; (xlii) 41.0-42.0 wt.% nickel; (xliii) 42.0-43.0 wt.% nickel; (xliv) 43.0-44.0 wt.% nickel; (xlv) 44.0-45.0 wt.% nickel; (xlvi) 45.0-46.0 wt.% nickel; (xlvii) > 46.0 wt.% nickel.

35 10. A mass spectrometer as claimed in any preceding claim, wherein said ion source and/or said one or more ionisation chambers and/or said one or more repeller electrodes forming part of said ion source comprise stainless steel or an alloy comprising:

(i) 0-1.0 wt.% molybdenum; (ii) 1.0-2.0 wt.% molybdenum; (iii) 2.0-3.0 wt.% molybdenum; (iv) 3.0-4.0 wt.% molybdenum; (v) 4.0-5.0 wt.% molybdenum; (vi) 5.0-6.0 wt.% molybdenum; (vii) 6.0-7.0 wt.% molybdenum; (viii) 7.0-8.0 wt.% molybdenum; and (ix) > 8.0 wt.% molybdenum.

- 12 -

11. A mass spectrometer as claimed in any preceding claim, wherein said ion source and/or said one or more ionisation chambers and/or said one or more repeller electrodes forming part of said ion source comprise stainless steel or an alloy comprising:

(i) 0-1.0 wt.% copper; (ii) 1.0-2.0 wt.% copper; (iii) 2.0-3.0 wt.% copper; (iv) 3.0-4.0 wt.% copper; and (v) > 4.0 wt.% copper.

12. A mass spectrometer as claimed in any preceding claim, wherein said ion source and/or said one or more ionisation chambers and/or said one or more repeller electrodes forming part of said ion source comprise stainless steel or an alloy comprising:

(i) 0.01-1.0 wt.% X; (ii) 1.0-2.0 wt.% X; (iii) 2.0-3.0 wt.% X; (iv) 3.0-4.0 wt.% X; and (v) > 4.0 wt.% X;

wherein X comprises cobalt and/or tantalum and/or aluminium and/or titanium and/or niobium and/or silicon and/or manganese and/or tungsten and/or phosphorous.

13. A mass spectrometer as claimed in any preceding claim, wherein said first coating or surface is provided on:

(i) at least 5%, 10%, 15%, 20%, 25%, 30%, 35%, 40%, 45%, 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95% or 100% of an inner surface and/or an outer surface of said ion source; and/or

(ii) at least 5%, 10%, 15%, 20%, 25%, 30%, 35%, 40%, 45%, 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95% or 100% of an inner surface and/or an outer surface of said one or more ionisation chambers; and/or

(iii) at least 5%, 10%, 15%, 20%, 25%, 30%, 35%, 40%, 45%, 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95% or 100% of an inner surface and/or an outer surface of said one or more repeller electrodes.

14. A mass spectrometer as claimed in any preceding claim, wherein said Diamond Like Carbon coating comprises a SP2 (graphite) to SP3 (diamond) ratio selected from the group consisting of: (i) < 0.1; (ii) 0.1-0.2; (iii) 0.2-0.3; (iv) 0.3-0.4; (v) 0.4-0.5; (vi) 0.5-0.6; (vii) 0.6-0.7; (viii) 0.7-0.8; (ix) 0.8-0.9; and (x) 0.9-1.0.

15. A mass spectrometer as claimed in any preceding claim, wherein said Diamond Like Carbon coating or surface comprises a carbon coating or surface having a diamond-like structure.

16. A mass spectrometer as claimed in any preceding claim, wherein said Diamond Like Carbon coating or surface further comprises a metal component.

17. A mass spectrometer as claimed in claim 16, wherein said metal component comprises chromium.

18. A mass spectrometer as claimed in any preceding claim, wherein said first coating or surface has either:

(a) a resistivity selected from the group consisting of: (i) $< 10^{-3} \Omega\text{-m}$; (ii) $< 10^{-4} \Omega\text{-m}$; (iii) $< 10^{-5} \Omega\text{-m}$; (iv) $< 10^{-6} \Omega\text{-m}$; (v) $< 10^{-7} \Omega\text{-m}$; (vi) $10^{-3}\text{-}10^{-4} \Omega\text{-m}$; (vii) $10^{-4}\text{-}10^{-5} \Omega\text{-m}$; (viii) $10^{-5}\text{-}10^{-6} \Omega\text{-m}$; and (ix) $10^{-6}\text{-}10^{-7} \Omega\text{-m}$; and/or

(b) a Vickers hardness number or Vickers Pyramid Number (HV) selected from the group consisting of: (i) > 1000 ; (ii) 1000-1100; (iii) 1100-1200; (iv) 1200-1300; (v) 1300-1400; (vi) 1400-1500; (vii) 1500-1600; (viii) 1600-1700; (ix) 1700-1800; (x) 1800-1900; (xi) 1900-2000; (xii) 2000-2100; (xiii) 2100-2200; (xiv) 2200-2300; (xv) 2300-2400; (xvi) 2400-2500; (xvii) 2500-2600; (xviii) 2600-2700; (xix) 2700-2800; (xx) 2800-2900; (xxi) 2900-3000; (xxii) 3000-3100; (xxiii) 3100-3200; (xxiv) 3200-3300; (xv) 3300-3400; (xvi) 3400-3500; and (xvii) > 3500 , wherein said Vickers hardness number or Vickers Pyramid Number is determined at a load of 30, 40, 50, 60 or 70 kg; and/or

(c) a Vickers microhardness selected from the group consisting of: (i) > 1000 kg/mm; (ii) 1000-1100 kg/mm; (iii) 1100-1200 kg/mm; (iv) 1200-1300 kg/mm; (v) 1300-1400 kg/mm; (vi) 1400-1500 kg/mm; (vii) 1500-1600 kg/mm; (viii) 1600-1700 kg/mm; (ix) 1700-1800 kg/mm; (x) 1800-1900 kg/mm; (xi) 1900-2000 kg/mm; (xii) 2000-2100 kg/mm; (xiii) 2100-2200 kg/mm; (xiv) 2200-2300 kg/mm; (xv) 2300-2400 kg/mm; (xvi) 2400-2500 kg/mm; (xvii) 2500-2600 kg/mm; (xviii) 2600-2700 kg/mm; (xix) 2700-2800 kg/mm; (xx) 2800-2900 kg/mm; (xxi) 2900-3000 kg/mm; (xxii) 3000-3100 kg/mm; (xxiii) 3100-3200 kg/mm; (xxiv) 3200-3300 kg/mm; (xv) 3300-3400 kg/mm; (xvi) 3400-3500 kg/mm; and (xvii) > 3500 kg/mm, and/or

(d) a thickness selected from the group consisting of: (i) $< 1 \mu\text{m}$; (ii) 1-2 μm ; (iii) 2-3 μm ; (iv) 3-4 μm ; (v) 4-5 μm ; (vi) 5-6 μm ; (vii) 6-7 μm ; (viii) 7-8 μm ; (ix) 8-9 μm ; (x) 9-10 μm ; (xi) $> 10 \mu\text{m}$; and/or

(e) a density selected from the group consisting of: (i) $< 3.0 \text{ g cm}^{-3}$; (ii) 3.0-3.5 g cm^{-3} ; (iii) 3.5-4.0 g cm^{-3} ; (iv) 4.0-4.5 g cm^{-3} ; (v) 4.5-5.0 g cm^{-3} ; (vi) 5.0-5.5 g cm^{-3} ; (vii) 5.5-6.0 g cm^{-3} ; (viii) 6.0-6.5 g cm^{-3} ; (ix) 6.5-7.0 g cm^{-3} ; (x) 7.0-7.5 g cm^{-3} ; (xi) 7.5-8.0 g cm^{-3} ; (xii) 8.0-8.5 g cm^{-3} ; (xiii) 8.5-9.0 g cm^{-3} ; (xiv) 9.0-9.5 g cm^{-3} ; (xv) 9.5-10.0 g cm^{-3} ; (xvi) 10.0-10.5 g cm^{-3} ; (xvii) 10.5-11.0 g cm^{-3} ; (xviii) 11.0-11.5 g cm^{-3} ; (xix) 11.5-12.0 g cm^{-3} ; (xx) 12.0-12.5 g cm^{-3} ; (xxi) 12.5-13.0 g cm^{-3} ; (xxii) 13.0-13.5 g cm^{-3} ; (xxiii) 13.5-14.0 g cm^{-3} ; (xxiv) 14.0-14.5 g cm^{-3} ; (xxv) 14.5-15.0 g cm^{-3} ; (xxvi) 15.0-15.5 g cm^{-3} ; (xxvii) 15.5-16.0 g cm^{-3} ; (xxviii) 16.0-16.5 g cm^{-3} ; (xxix) 16.5-17.0 g cm^{-3} ; (xxx) 17.0-17.5 g cm^{-3} ; (xxxi) 17.5-18.0 g cm^{-3} ; (xxxii) 18.0-18.5 g cm^{-3} ; (xxxiii) 18.5-19.0 g cm^{-3} ; (xxxiv) 19.0-19.5 g cm^{-3} ; (xxxv) 19.5-20.0 g cm^{-3} ; and (xxxvi) $> 20.0 \text{ g cm}^{-3}$; and/or

(f) a coefficient of friction selected from the group consisting of: (i) < 0.01 ; (ii) 0.01-0.02; (iii) 0.02-0.03; (iv) 0.03-0.04; (v) 0.04-0.05; (vi) 0.05-0.06; (vii) 0.06-0.07; (viii) 0.07-0.08; (ix) 0.08-0.09; (x) 0.09-0.10; and (xi) > 0.1 .

19. A mass spectrometer as claimed in any preceding claim, wherein said portion of said ion source having said first coating or surface is selected from the group consisting of:

(i) an ion chamber; (ii) a repeller electrode; and (iii) an exit plate or exit aperture arranged at the exit of said ion source through which ions of interest are desired to be transmitted.

20. A mass spectrometer as claimed in any preceding claim, wherein said ion source is selected from the group consisting of: (i) an Electrospray ionisation ("ESI") ion source; (ii) an Atmospheric Pressure Photo Ionisation ("APPI") ion source; (iii) an Atmospheric Pressure Chemical Ionisation ("APCI") ion source; (iv) a Matrix Assisted Laser Desorption Ionisation ("MALDI") ion source; (v) a Laser Desorption Ionisation ("LDI") ion source; (vi) an Atmospheric Pressure Ionisation ("API") ion source; (vii) a Desorption Ionisation on Silicon ("DIOS") ion source; (viii) an Electron Impact ("EI") ion source; (ix) a Chemical Ionisation ("CI") ion source; (x) a Field Ionisation ("FI") ion source; (xi) a Field Desorption ("FD") ion source; (xii) an Inductively Coupled Plasma ("ICP") ion source; (xiii) a Fast Atom Bombardment ("FAB") ion source; (xiv) a Liquid Secondary Ion Mass Spectrometry ("LSIMS") ion source; (xv) a Desorption Electrospray Ionisation ("DESI") ion source; (xvi) a Nickel-63 radioactive ion source; (xvii) an Atmospheric Pressure Matrix Assisted Laser Desorption Ionisation ion source; (xviii) a Thermospray ion source; (xix) an Atmospheric Sampling Glow Discharge Ionisation ("ASGDI") ion source; and (xx) a Glow Discharge ("GD") ion source.

21. A method of mass spectrometry comprising:
ionising ions in an ion source having a first coating or surface provided on at least a portion of said ion source, wherein said first coating or surface comprises a Diamond Like Carbon ("DLC") coating or surface.

22. A method of making an ion source and/or one or more ionisation chambers and/or one or more repeller electrodes forming part of an ion source for a mass spectrometer comprising:
depositing, sputtering or forming a first coating or surface on at least a portion of an ion source and/or one or more ionisation chambers and/or one or more repeller electrodes forming part of said ion source, wherein said first coating or surface comprises a Diamond Like Carbon ("DLC") coating or surface.

23. A method as claimed in claim 22, wherein said step of depositing, sputtering or forming said first coating or surface comprises using a method selected from the group consisting of: (i) magnetron sputtering; (ii) closed field unbalanced magnetron sputter ion plating; (iii) electroplating; (iv) thermal spray coating; (v) vapour deposition; (vi) Chemical Vapour Deposition ("CVD"); (vii) combustion torch/flame spraying; (viii) electric arc spraying; (ix) plasma spraying; (x) ion plating; (xi) ion implantation; (xii) sputtering; (xiii) sputter deposition; (xiv) laser surface alloying; (xv) Physical Vapour Deposition ("PVD"); (xvi) plasma-based ion plating; (xvii) gas plasma discharge sputtering; (xviii) laser cladding; (xix) plasma enhanced Chemical Vapour Deposition; (xx) low pressure Chemical Vapour Deposition; (xxi) laser enhanced Chemical Vapour Deposition; (xxii) active reactive

evaporation; (xxiii) Pulsed Laser Deposition ("PLD"); (xxiv) RF-sputtering; (xxv) Ion-Beam Sputtering ("IBS"); (xxvi) reactive sputtering; (xxvii) Ion-Assisted Deposition ("IAD"); (xxviii) high target utilisation sputtering; (xxix) High Power Impulse Magnetron Sputtering ("HIPIMS"); and (xxx) DC-sputtering.

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24. A method as claimed in claim 22 or 23, wherein said step of depositing, sputtering or forming said first coating or surface comprises creating a glow or RF discharge to said ion source and/or said one or more ionisation chambers and/or said one or more repeller electrodes forming part of said ion source in an atmosphere containing a hydrocarbon gas, wherein said glow or RF discharge causes a breakdown of said hydrocarbon gas so that carbon from said gas is deposited on said ion source and/or said one or more ionisation chambers and/or said one or more repeller electrodes forming part of said ion source.

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25. A method as claimed in any of claims 22, 23 or 24, wherein said step of depositing, sputtering or forming said first coating or surface comprises applying a pulsed DC biased power supply to said ion source and/or said one or more ionisation chambers and/or said one or more repeller electrodes forming part of said ion source in an atmosphere containing a hydrocarbon gas, wherein said pulsed DC biased power supply causes a breakdown of said hydrocarbon gas so that carbon from said gas is deposited on said ion source and/or said one or more ionisation chambers and/or said one or more repeller electrodes forming part of said ion source.

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26. A method as claimed in claim 24 or 25, wherein said hydrocarbon gas comprises butane.

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27. A method as claimed in claim 24, 25 or 26, wherein said step of depositing, sputtering or forming said first coating or surface further comprises simultaneously depositing a metal with the deposition of carbon from said hydrocarbon gas to form a Diamond Like Carbon coating or surface including a metal therein.

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28. A method as claimed in claim 27, wherein said metal comprises chromium.

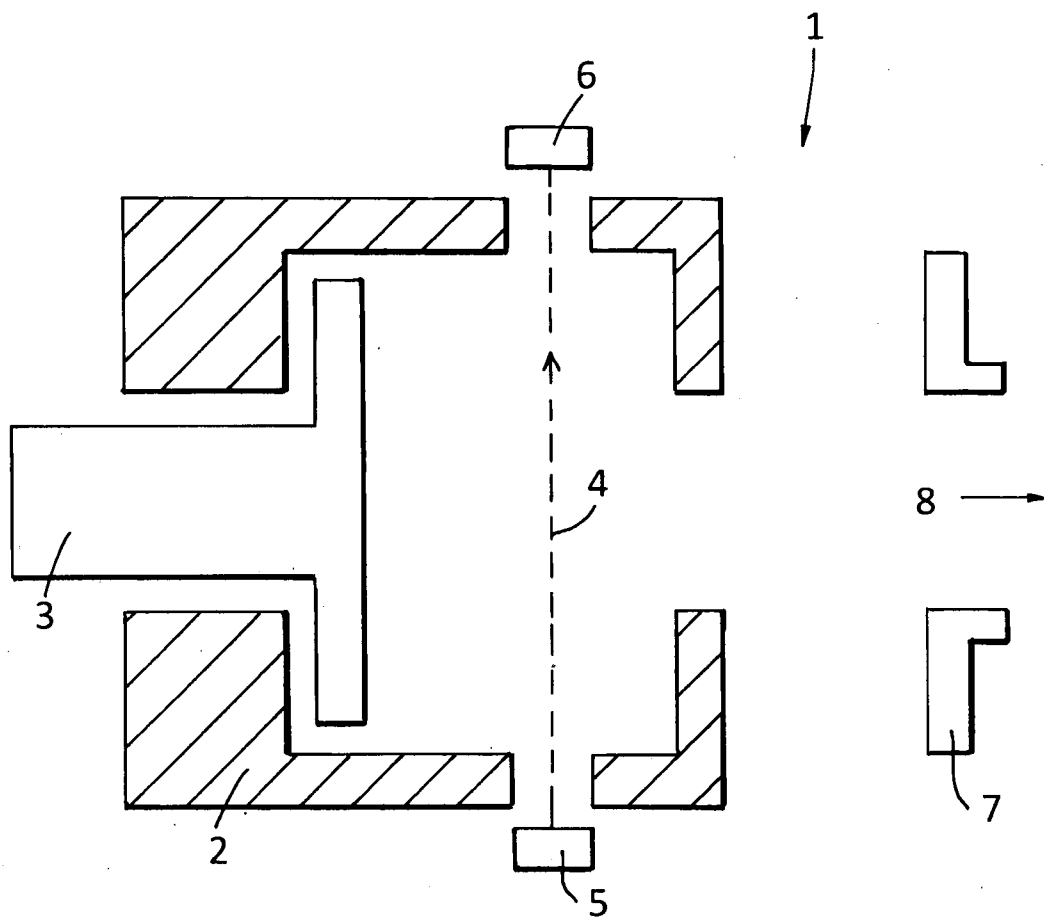


FIG. 1

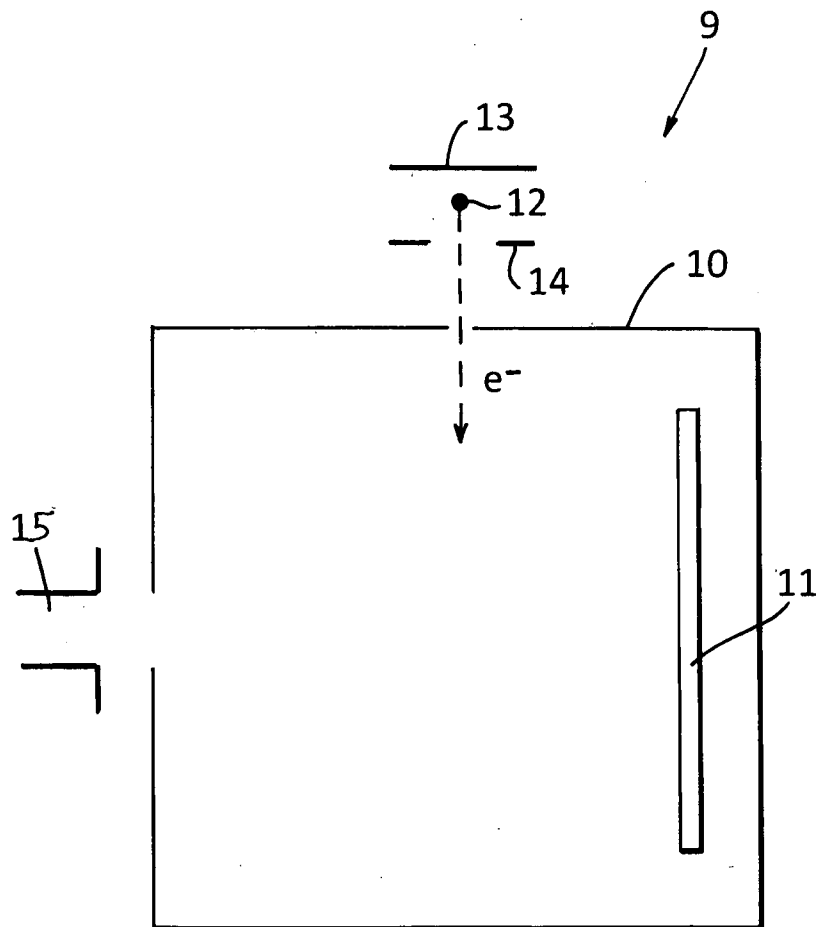
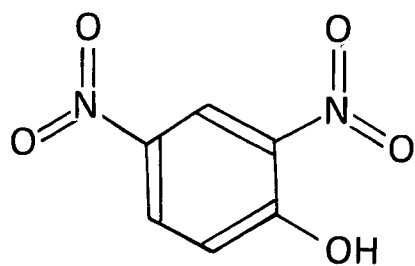
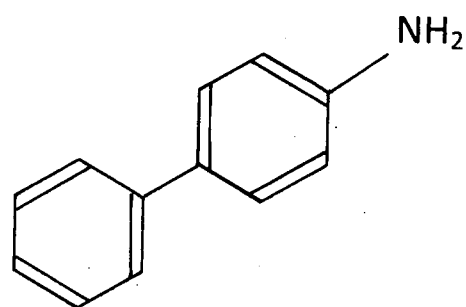


FIG. 2



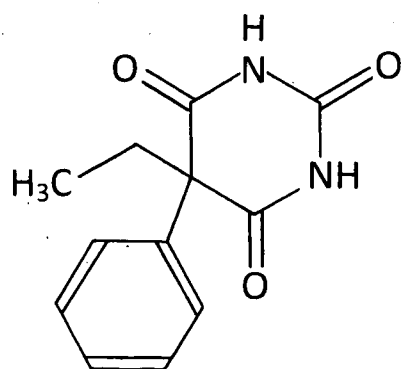
2, 4 dinitrophenol. $C_6 H_4 N_2 O_5$

FIG. 3



4 amino biphenyl, $C_{12} H_{11} N$

FIG. 4



Phenobarbital, $C_{12} H_{12} N_2 O_3$

FIG. 5

Compound	% increase initial	S : N (RMS)	Signal	Noise amplitude	Area
2,4 dinitrophenol	TiC	2.04	3.14	1.46	3.60
2,4 dinitrophenol	Cleaned stainless steel	0.60	1.62	2.66	1.87
4 amino biphenyl	TiC	1.27	1.59	1.14	1.55
4 amino biphenyl	Cleaned stainless steel	1.90	3.31	1.73	2.84
Phenobarbital	TiC	1.74	2.55	1.52	2.99
Phenobarbital	Cleaned stainless steel	0.60	1.27	2.36	1.57

FIG. 6

Compound	% increase initial	S : N (RMS)	Signal	Noise amplitude	Area
2,4 dinitrophenol	TiC	3.38	1.94	0.55	1.92
4 amino biphenyl	TiC	0.67	0.48	0.66	0.54
Phenobarbital	TiC	2.91	2.01	0.64	1.91

FIG. 7

INTERNATIONAL SEARCH REPORT

International application No

PCT/GB2010/000964

A. CLASSIFICATION OF SUBJECT MATTER

INV. H01J49/10 H01J49/14
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H01J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2004 186113 A (SAKAGUCHI GIKEN KK; SUZUKI TSUTOMU) 2 July 2004 (2004-07-02) * abstract	1-28
X	KR 2009 0015392 A (KOREA ADVANCED INST SCI & TECH [KR]) 12 February 2009 (2009-02-12) paragraph [0023]	1-28
T	Deutchman, A.H., Partyka, R.J.: "Industrial Diamond and Diamondlike Films" In: Arthur A. Tracton: "Coatings Technology Handbook" 2005, CRC Press, XP008124164 ISBN: 978-1-57444-649-4, pages 33-1-33-6 pages 33-3 - pages 33-5	1-30

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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Date of the actual completion of the international search

29 July 2010

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/GB2010/000964

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 2004186113 A	02-07-2004	NONE	
KR 20090015392 A	12-02-2009	NONE	