(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
27 December 2007 (27.12.2007)

PCT

(10) International Publication Number
WO 2007/149534 A3

(51) International Patent Classification:
G12B 21/06 (2006.01) *G01N 21/65* (2006.01)
G01N 13/14 (2006.01) *G02B 27/56* (2006.01)

(21) International Application Number:
PCT/US2007/014480

(22) International Filing Date: 21 June 2007 (21.06.2007)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/805,370 21 June 2006 (21.06.2006) US

(71) Applicant *(for all designated States except US)*: **UNIVERSITY OF DAYTON** [US/US]; 300 College Park, Dayton, OH 45469-0101 (US).

(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: **ZHAN, Qiwen** [CN/US]; 6821 Gentry Lane, Mason, OH 45040 (US).

(74) Agents: **SWANSON, Kristina, E.** et al.; Dinsmore & Shohl LLP, One Dayton Centre, Suite 1300, One South Main Street, Dayton, OH 45402-2023 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

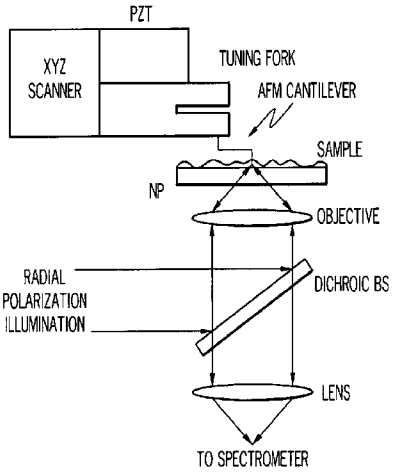
— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

Published:

— *with international search report*

[Continued on next page]

(54) Title: METHODS OF POLARIZATION ENGINEERING AND THEIR APPLICATIONS



(57) Abstract: Special polarization states are generated that have unique focusing properties that may be used to create extremely strong longitudinal fields. Combined with surface plasmon excitation, these polarization states can be used in apertureless near-field scanning optical microscopy systems. A radially polarized beam is directed into a plasmon-generating optical fiber comprising a metal coated, tapered, apertureless tip. The apertureless tip excites surface plasmon waves and direct the surface plasmon waves to the tip when a radially polarized beam propagates along the plasmon-generating optical fiber. An objective lens collects the near field optical signals from a sample positioned adjacent to the apertureless. Potential spatial resolution of the apertureless NSOM could reach beyond 10 nm. Such strong field enhancement allows the development of a reliable nano-Raman system that can measure mechanical as well as chemical compositions of samples with resolution beyond 10 nm.

WO 2007/149534 A3

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

(88) Date of publication of the international search report:
12 June 2008

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2007/014480

A. CLASSIFICATION OF SUBJECT MATTER
INV. G12B21/06 G01N13/14 G01N21/65 G02B27/56

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)
G01N G02B

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, INSPEC, COMPENDEX, BIOSIS, EMBASE, IBM-TDB

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2004/003932 A (SEAGATE TECHNOLOGY LLC [US]) 8 January 2004 (2004-01-08) figures 10-17 page 14, line 4 - page 16, line 13	1-22
Y	HAYAZAWA NORIHIKO ET AL: "Detection and characterization of longitudinal field for tip-enhanced Raman spectroscopy" APPLIED PHYSICS LETTERS, AIP, AMERICAN INSTITUTE OF PHYSICS, MELVILLE, NY, US, vol. 85, no. 25, 20 December 2004 (2004-12-20), pages 6239-6241, XP012063907 ISSN: 0003-6951 the whole document	1-22

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
7 March 2008	24/04/2008

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Polesello, Paolo

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2007/014480

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	AYARS E J ET AL: "Fundamental differences between micro- and nano-Raman spectroscopy" JOURNAL OF MICROSCOPY BLACKWELL SCIENCE UK, vol. 202, April 2001 (2001-04), pages 142-147, XP002471989 ISSN: 0022-2720 cited in the application paragraph [EXPERIMENTAL]	1-22
A	ZHAN Q: "PROPERTIES OF CIRCULARLY POLARIZED VORTEX BEAMS" OPTICS LETTERS, OSA, OPTICAL SOCIETY OF AMERICA, WASHINGTON, DC, US, vol. 31, no. 7, 1 April 2006 (2006-04-01), pages 867-869, XP001242334 ISSN: 0146-9592 the whole document	22
A	KURIHARA K ET AL: "Fiber-optic conical microsensors for surface plasmon resonance using chemically etched single-mode fiber" ANALYTICA CHIMICA ACTA, ELSEVIER, AMSTERDAM, NL, vol. 523, no. 2, 11 October 2004 (2004-10-11), pages 165-170, XP004564422 ISSN: 0003-2670 figure 1 paragraph [0002]	1-22
A	INOUYE Y ET AL: "Near-field scanning optical microscope using a metallized cantilever tip for nanospectroscopy" PROCEEDINGS OF THE SPIE - THE INTERNATIONAL SOCIETY FOR OPTICAL ENGINEERING SPIE-INT. SOC. OPT. ENG USA, vol. 3791, 1999, pages 40-48, XP002471990 ISSN: 0277-786X the whole document	1-22
A	WO 02/068919 A (UNIV SINGAPORE [SG]; SHEN ZE XIANG [SG]; SUN WANXIN [SG]) 6 September 2002 (2002-09-06) figures 1-3 page 7, line 1 - page 10, line 3	1-22

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2007/014480

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers allsearchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search reportcovers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-22

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-22

   Near field optical system wherein a radially polarized or a cicularly polarized vortex beam is introduced into an apertureless metal coated optical fiber probe configured to excite surface plasmon waves to the apex of the probe and wherein the near field signal from a sample near the probe is collected by an objective lens.

   ---

2. claims: 23-25

   System for generating evanescent Bessel beams wherein a radially polarized beam is focalized by an aplanatic lens onto an interface of a thin metal film/dielectric substrate.

   ---

3. claims: 26-35

   System for generating a cylindrical vector beam comprising a laser beam source, a radial analyzer, an e-beam written spiral phase element and a double half-wave-plate polarization rotator or a lens and an optical fiber.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2007/014480

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2004003932 A	08-01-2004	AU 2003218265 A1	19-01-2004
		CN 1666298 A	07-09-2005
WO 02068919 A	06-09-2002	EP 1370839 A1	17-12-2003
		JP 2004533604 T	04-11-2004