

COMMONWEALTH OF AUSTRALIA

59 8244 ^{7185/87}

APPLICATION ACCEPTED AND AMENDMENTS

Patents Act 1952

ALLOWED 5-7-90

CONVENTION APPLICATION FOR A STANDARD PATENT

WE, KERNFORSCHUNGSZENTRUM KARLSRUHE GMBH, a limited liability company of Postfach 3640 D-7500 Karlsruhe 1, Federal Republic of Germany

hereby apply for the grant of a Standard Patent for an invention entitled CATALYST CARRIER AND METHOD OF PRODUCING SAME

which is described in the accompanying complete specification.

This application is made under the provision of Part XVI of the Patents Act 1952 and is based on an application for a patent or similar protection made

in Federal Republic of Germany

on 8 April 1986

No. (P36 11 732.3-41)

or

No. (

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- 8 APR 1987
Sydney

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Dated this 8th day of April 1987

KERNFORSCHUNGSZENTRUM KARLSRUHE GMBH

By:

Registered Patent Attorney

TO: The Commissioner of Patents,
COMMONWEALTH OF AUSTRALIA

Commonwealth of Australia
The Patents Act 1952
DECLARATION IN SUPPORT

In support of the (Convention) Application made by:
KERNFORSCHUNGSZENTRUM KARLSRUHE GMBH, of Postfach 3640 D-7500 Karlsruhe 1,
Federal Republic of Germany

for a patent for an invention entitled:
CATALYST CARRIER AND METHOD OF PRODUCING SAME

I ~~(We)~~ Peter Gottlob, Patent Assessor
of and care of the applicant company do solemnly and sincerely declare as follows:

~~I am (We are) the applicant(s) for the patent~~

~~or~~

b) I am ~~(We are)~~ authorised by the applicant(s) for the patent to make this declaration on its behalf.

Delete the following if not a Convention Application.

The basic application(s) as defined by section 141 ~~(142)~~ of the Act was ~~(were)~~ made

in Federal Republic of Germany on 8 April 1986

~~or~~

~~or~~

~~or~~

~~or~~

by the present applicant company

The basic application(s) referred to in this paragraph is ~~(are)~~ the first application(s) made in a Convention country in respect of the invention the subject of the application.

~~I am (We are) the actual inventor(s) of the invention~~

~~or~~

b) Herr Dr. Wolfgang Ehrfeld, of Reutstrasse 27, 7500 Karlsruhe 41
Herr Dr. Asim Maner, of Zwelfmorgen 8, 7515 Linkenheim-Ho.1.
Federal Republic of Germany

~~I~~(are) the actual inventor(s) of the invention and the facts upon which
the applicant company

is ~~(are)~~ entitled to make the application are as follows:

the applicant is a person who would if a patent were granted upon an application made by the actual inventor, be entitled to have the patent assigned to it

Declared at Karlsruhe this 2 day of April 19 87

Signed *P. Gottlob* Status Patentassessor
Peter Gottlob

Declarant's Name

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(57) Claim

1. A catalyst carrier for catalytic reactions of two or more reaction partners, being formed from metal or ceramics and produced from individual plate-like microstructural bodies which are situated one above the other in layers and are aligned with one another, said bodies being combined to form a stable body and being produced by X-ray deep-etch lithography and microgalvanic moulding or by a microdeforming technique derived therefrom (LIGA method), wherein channels are formed in the stable body.

5. A method of producing catalyst carriers comprising situating plate-like microstructural bodies produced by X-ray deep-etch lithography and microgalvanic moulding or by a microdeforming technique derived therefrom (LIGA method) one above the other in layers, aligning with one another and combining to form a stable body.

BACKGROUND OF THE INVENTION

The present invention relates to carriers having a basic structure of metal or ceramic, for a catalyst for catalytic reactions of two or more reaction partners, and to a method
5 of producing such carriers.

A method employed particularly frequently in the production of heterogeneous catalysts is the impregnation of a porous carrier with a solution, a melt or a gaseous compound, constituting a saturation catalyst. In this case,
10 the catalytically active basic substance - possibly together with a so-called promoter which supports the catalytic effect of the basic substance with respect to activity or selectivity - is distributed in finely dispersed form on the surface of the carrier. Today, synthetically produced
15 substances whose porosity can be varied over a broad range are usually used as carrier materials. Customary substances are, for example, aluminum oxide, silica gel, activated carbon, silicon carbide, titanium dioxide, various silicates and zeolites. Numerous processes have been developed to
20 shape the carrier. Customarily employed are, in particular, pelletizing, tabletizing and extrusion molding. If noble metal catalysts are employed, simple nets made of thin noble metal wires are employed in some cases.

A number of factors must be considered for the optimization of the catalyst carrier. In addition to the magnitude of the total pore surface area on which the catalytically active substance is distributed, the shape of the pores also plays a decisive part. For example, if the pores are deep, the desired conversion may already be realized within a path which is only a fraction of the pore depth so that the sometimes very expensive active substance in the lower part of the pores is utilized only incompletely, i.e. there results a low degree of pore utilization. Additionally, if the reacting substances and the reaction products experience longer periods of dwell in the pores, the selectivity of the catalytic reaction may be reduced by undesirable secondary reactions.

Particularly for reactions of gaseous components and high gas throughput rates, the pressure loss occurring in the reaction chamber is also quite significant. For automatic decontamination of the exhaust and industrial gases, special catalyst carriers have therefore been developed which are provided with channels extending in the direction of flow and are called monoliths or honeycomb bodies. They are compact bodies, usually cylindrical or oval, composed of only one piece. The shape of the channels visible in a cross section may then be, for example, a triangle, square, hexagon or circle. In the direction of flow, the channels may be linear or serpentine.

The materials employed for such catalyst carriers are thermally and mechanically highly stressable substances, e.g. cordierite, mullite, aluminum oxide, silicon carbide and metal alloys (see Ullmann's "Enzyklopädie der technischen Chemie" [Encyclopedia of Chemical Engineering], Volume 13
5 (1977), pages 560-562).

The catalyst carriers are manufactured by extrusion or according to the winding method in which corrugated metal sheets or corrugated thin sheets coated with a ceramic
10 material are wound into a coil. In many cases, the channel surface is not porous but smooth. Before the catalyst carrier is covered with a catalytically active substance, it is then necessary to coat it with a substance which enlarges its surface area, e.g. with activated alumina.

15 The efficiency and economy of a saturated catalyst thus decisively depends on the selection of a suitable catalyst carrier and the subsequent treatment steps. It is immediately evident that the problems of substance transfer, reaction and flow processes on the one hand and the problems
20 of mechanical and thermal stability on the other hand must be considered together and that, from an economic point of view, the costs for the materials, particularly with respect to the expensive catalyst substance, also plays an important part.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide catalyst carriers which can be used for various purposes and a method of manufacturing such catalyst carriers in which the multifaceted requirements to be met by a heterogeneous catalyst can be met with particular flexibility.

In particular, the invention seeks to provide a superior combination of characteristics to enhance substance exchange, low pressure drops, costs for materials and reduce structural size compared to prior art catalyst carriers.

Accordingly, a first aspect of the present invention provides a catalyst carrier for catalytic reactions of two or more reaction partners, ^{being formed from} ~~having a basic structure of~~ metal or ceramics, ^{and} produced from individual plate-like microstructural bodies which are situated one above the other in layers and are aligned with one another, said bodies being combined to form a stable body and being produced by X-ray deep-etch lithography and microgalvanic moulding or by a microdeforming technique derived therefrom (LIGA method), wherein channels are formed in the stable body.

In a second aspect, the present invention provides a method of producing catalyst carriers, wherein individual plate-like microstructural bodies, produced by X-ray deep-etch lithography and microgalvanic moulding or by a microdeforming technique derived therefrom (LIGA method), are situated one above the other in layers, are aligned with one another and are combined to form a stable body.



The
~~According to the invention, the~~ body can be formed by microgalvanic shaping or according to a micromolding technique. The negative mold used to form the body can be that which is directly produced by lithography or a copy
5 produced therefrom.

The objects according to the invention are ~~further~~ achieved by the provision of a catalyst carrier composed of several layers of the body described above.

One of the techniques involved in producing a
10 plate-shaped, microstructured body is the fabricating of a plastic template by means of X-ray deep-etch lithography filling the gaps of this template with metal by electrodeposition and removing the plastic template hereafter to attain a metal body of the desired shape.

15 Another technique employs a metal body produced as described above as a mold insert to produce numerous negative replicas of the metal body in synthetic material which are filled with metal by electrodeposition afterwards. Removing the synthetic material from the gaps
20 of the structures delivers plate-shaped, microstructured bodies of metal finally. This second technique can in some cases represent a more economical production method as the X-ray deep-etch lithography is only involved in making a single mold insert. A modification of the second
25 method is used to obtain plate-shaped, microstructured bodies of ceramic material. In this case the mold insert produced by X-ray deep-etch lithography and electroplating is molded with a substance composed of a fine



ceramic powder and a binder or a liquid chemical substance which can be transformed in a ceramic material by heat treatment. In addition, plate-shaped, microstructured bodies of sintered metal can be obtained by molding the mold insert with a substance consisting of a metal powder and a binder and subsequent heat treatment.

The production of microstructured bodies according to the LIGA method is described, inter alia, in KfK-Bericht [Report] 3995 by Kernforschungszentrum Karlsruhe, dated November 1985. This method basically involves deep radiation lithography with synchrotron radiation, electroforming and synthetic material molding.

According to one example of the method described in that report, an X-ray sensitive positive resist material is applied to a metal base plate and is partially irradiated with X-rays, through a mask, and developed so that a negative mold of a plate-shaped microstructured body results. The height of the negative mold corresponds to the layer thickness of the resist material; depending on the penetration depth of the X-ray radiation, it may be up to 2 mm. Thereafter, the negative mold is galvanically filled with a metal, employing the base plate as the electrode, whereupon the remaining resist material is removed by means of a solvent. The metal structure thus produced by X-ray deep-etch lithography and microgalvanic shaping can be used to produce many plastic molds which themselves can be filled, for example, by galvanic deposition of metal, whereupon the plastic is then removed.

With this technique, it is possible to produce extremely accurate and fine structures having lateral dimensions in the micron range and with a freely selectable height up to about 2 mm. For somewhat lower heights, minimum lateral dimensions
5 in the submicron range can also be realized.

The plate-shaped microstructured bodies produced with this technique for the construction of catalyst carriers may be plates with a plurality of holes having, for example, a hexagonal form. Plates provided with webs up to 2 mm in
10 height and a width of a few microns can be produced in almost any desired length according to the same technique. This possibility of giving the holes or webs or other structures of the plate-shaped microstructured bodies any desired shape permits optimum consideration of the aspects of intensive
15 substance transport from the fluid phase to the solid wall and satisfaction of the requirements for the lowest possible pressure losses during flow through a catalyst carrier composed of the microstructured bodies.

Due to the small dimensions of the holes or webs, a
20 favorable ratio of surface to volume of the catalyst carrier can be realized already without any additional measures for surface area enlargement. Compared to the prior art noble metal nets mentioned above, there is already realized an improvement in efficiency since, with simultaneous enlarge-
25 ment of the specific catalyst surface, it is possible to increase transparency, i.e. the percentage of the cross-

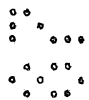
sectional area through which free flow is possible and thus a reduction in the drop in pressure. If noble metals are employed, the carrier and catalytically active substance may be identical.

5 According to an advantageous feature of the invention, the plate-shaped microstructures, before being impregnated with a catalytically active substance, are covered with a substance which enlarges their surface area, e.g. with activated alumina. This coverage may also be effected by
10 known methods of thin-film technology, such as chemical vapor deposition (CVD) or physical vapor deposition (PVD), with the coating possibly being made microporous by means of a further process. An example for this is coating with aluminum by vapor deposition and subsequent oxidation of the
15 vapor-deposited aluminum layer. A particular advantage of this method is that, on the one hand, the large number of individual microstructures already gives the microstructured body a comparatively large surface area and that, on the other hand, coating this surface with a porous layer can
20 further increase this surface area, with the structure and depth of the pores being determined in a defined manner by the production and subsequent treatment of the layer.

 A further advantageous possibility for enlarging the surface area of the microstructured bodies resides in that,
25 during microgalvanic shaping, microstructured bodies are produced from a metal alloy or a metal matrix containing

microdispersed particles and that subsequently components of the metal alloy or of the metal matrix, respectively, are removed, for example by dissolving or heating. In this way, catalyst carriers are produced which have a highly active surface and which correspond to the prior art skeleton catalysts.

By using molding substances composed of a fine ceramic and/or metal powder and a binder, plate-shaped microstructured bodies can be produced directly as sintered bodies, with correspondingly large surface area. It is then possible to either fill a negative mold produced according to the molding process with the above-mentioned molding substance or to produce the microstructured body by filling a tool whose shape corresponds to the negative of the desired microstructured body with the above-mentioned molding substance. In this case, further substances are advisably added to the molding substance as antifriction agents and as release agents to facilitate filling of the tool with the molding substance and the subsequent unmolding of the hardened microstructured body. The unmolded, hardened microstructured body is customarily subjected to a heat treatment in which the binder is removed and the microstructured body is solidified by sintering.



A particularly simple way to enlarge the surface area of plate-shaped microstructured bodies is to produce the negative from a molding substance made up of a plurality of components for the production of the negative. Suitable for this purpose is, for example, a molding substance composed of styrene, divinyl benzene and polyvinyl acetate. During the copolymerization of styrene and divinyl benzene, which are additionally cross-linked, polyvinyl acetate is incorporated as an inert component which can subsequently be dissolved out, producing a permanently porous copolymer. By introducing the above-mentioned molding substance composed of a ceramic powder and/or a metal powder and a binder into the porous negative of the microstructured body, a microstructured body is produced which has a large surface area. Likewise, a metal microstructured body can be produced by microgalvanic shaping and this body, corresponding to the porous wall structure of the negative, has a correspondingly enlarged surface area.

The invention will now be described in greater detail with reference to the drawing.

BRIEF DESCRIPTION OF THE DRAWING

Figures 1-3 are elevational views of successive stages in the production of a microstructured body according to the invention.

Figure 4 is an elevational view of one suitable embodiment of a catalyst carrier composed of a stack of microstructured bodies according to the invention.

5 Figures 5-8 are elevational views of successive stages in the production of a microstructured body according to another embodiment of the invention.

Figures 9 and 12 are perspective of catalyst carriers composed of microstructured bodies according to the invention.

10 Figures 10 and 11 are plan views of exemplary microstructure recess configurations according to the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

15 Figure 1 is a sectional view showing a metal layer 12 on which a layer 11 of a substance, e.g. resist, whose characteristics can be changed by X-ray radiation has been applied. By partial irradiation with synchrotron radiation 13 through an X-ray mask 14 composed of a carrier foil 15 essentially transparent to X-rays and absorber structures 16, the irradiated regions 17 of resist layer 11 are changed in a chemical manner, thus increasing their solubility.

20 By dissolving regions 17, a relief-like microstructure 21 of plastic results which has exposed regions 22 as shown in Figure 2. These exposed regions 22 are filled with metal by galvanic deposition, and then the plastic microstructure 25 21 and metal layers 12 are removed.

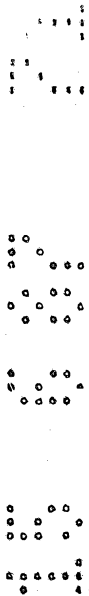
As shown in Figure 3, this results in a plate-shaped microstructured body 33 composed of passages 31 and walls 32.

As shown in Figure 4, a plurality of these
5 microstructured bodies can be stacked, aligned and combined into a stable body 41 representing the catalyst carrier. During the alignment of the microstructured bodies, the passage walls 32 of one body are offset with respect to the adjacent bodies to improve substance
10 transfer to the walls which are coated with a catalytically active basic substance. The arrows identify the major flow direction of the reaction partners.

To increase the catalytically active surface area, a microstructure 52 can be disposed on a base plate 53 and
15 coated, as shown in Figure 5, with a substance 51. The walls here have the shape, for example, of ribs which extend in the direction of flow or are placed at an angle with respect to the direction of flow. A chemical process can then convert layer 51 to a microporous coating 64,
20 shown in Figure 6.

The plate-shaped, microstructured bodies consisting of a base plate 53, a microstructure 52 and a microporous coating 64 as shown in Figures 5 and 6 are stacked and combined into a stable body representing the catalyst carrier. In contrast to the catalyst carrier shown in Figure 4 where the major flow direction of the reaction partners is parallel to the stack direction, the reaction partners flow perpendicular to the stack direction in this case. The coating and the chemical process for converting layer 51 to a microporous coating 64 can also be performed after combining the microstructure bodies into the stable body representing the catalyst carrier. A stack of plate-shaped, microstructured bodies forming a catalyst carrier is shown in Figure 12. Another way of forming a stable body representing the catalyst carrier is the winding method in which a microstructure body as shown in Figure 6 is wound to a coil.

Figure 7 is a schematic representation of microporous structures 71 as they can be produced by the deposition of a metal alloy on a carrier plate 72 and subsequent dissolving out of one component of the alloy (skeleton catalyst). To produce the microporous structures 71, first a X-ray sensitive positive resist material is applied to the carrier plate 72 and is partially irradiated with X-rays, through a mask, and developed so that a negative mold results. Thereafter, the negative mold is galvanically filled with a metal alloy, employing the carrier plate 72 as the electrode, whereupon the remaining resist material is removed, e.g. by means of a solvent. Subsequently one component of the alloy is dissolved out leaving the microporous structures 71 on the carrier plate. In this case the carrier plate 72 corresponds to substrate 12 of Figures 1 and 2. As an alloy, for example, a copper-nickel composition can be deposited on a carrier plate 72 of nickel. A solution containing copper chloride and ammonia is a suitable solvent to remove copper selectively from the alloy. Another possibility of producing the microporous structures 71 is that the negative mold employed is fabricated by the plastic molding process instead of by the X-ray lithography. The procedure



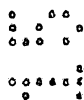
of electrodeposition of an alloy and the subsequent dissolving of one component of the alloy will be the same in this case. A further method of producing the microporous structures 71 is the employment of a two component resist or molding plastic in producing the negative mold by X-ray lithography or plastic molding respectively. The negative mold is then etched with a suitable solvent or is subject to a heat treatment, whereby one component of the plastic material is removed. Thus a negative mold with porous walls are obtained, which will produce a microporous structure 71 of metal when it is filled with metal by electroposition. Such a composite material employable in producing a negative mold with porous walls is also a composite material consisting of a polymer and metal powder. The metal particles in the walls can be etched in a mineral acid leaving porous walls of polymer in the negative mold. Further techniques for producing porous molds are well-known from membrane technology e.g. polymerization of cellulosis acetate.

Figure 8 is a schematic representation of microstructures 81 disposed on a base plate 82, with the shaping of the plate-shaped microstructured bodies being effected by the molding method, the molding substance containing a ceramic and/or metal powder and a binder, with a sintering process following after hardening of the molding substance. To produce the microstructures 81 disposed on the base plate 82 in Figure 8 first a negative mold

of metal consisting of a metal layer 12, a plate-shaped, microstructured body 33 composed of passages 31 and walls 32 thereon is fabricated according to Figures 1, 2, and 3. In a next step this negative mold of metal is filled and is cast over with a ceramic and/or metal powder and a binder. After hardening, unmolding, and sintering the embodiment shown in Figure 8 is obtained, where the microstructures 81 has been formed by molding the negative mold of metal and the base plate has been formed by the molding substance cast over the negative mold of metal.

Figure 9 is an illustration of a catalyst carrier 91 which, like the carrier of Figure 4 is composed of offset plate-shaped microstructured bodies 92 containing channels 93 whose channel walls 94 are provided with ribs 115 which extend into the channels, as shown in Figure 10. Figure 11 shows, as an alternative, a channel 113 having a rectangular cross section and delimited by channel walls 114 provided with primary ribs 115 and secondary ribs 116, both having recesses 117.

10 Figure 12 shows a stack of plate-shaped microstructured bodies 122 which, when assembled, form a catalyst carrier 121. Corrugated ribs 123 are applied to the microstructured bodies in an offset arrangement so as to increase the surface area, increase stability and
15 improve substance transfer. The improvement of the substance transfer by the offset arrangement is based on the fact that in a laminar flow the concentration of the reacting substances decrease rapidly in the vicinity of the catalytically active wall whereas this concentration
20 is



relatively high in the core of the flow. In the offset arrangement the catalytically active wall is periodically shifted to the high concentration region of the flow thus improving the substance transfer by reducing the diffusion path of the reacting substances to the wall.

It must here be pointed out expressly that the scope of the invention includes the use of individual microstructured bodies as catalyst carriers. The invention also of course includes such catalyst carriers in which microstructured bodies produced according to the invention and provided with ribs applied to base plates are wound into a compact catalyst carrier.

The production of a stack of plate-shaped microstructured bodies which, when assembled, form a catalyst carrier according to Figure 12 was verified by laboratory-scale experiments. The procedure will be described in detail below.

To produce the embodiment shown in Figure 2 a plate of high-grade steel (material No. 1.4301) is used for the metal layer 12. Resist layer 11 is produced by pouring on a non-

crosslinking casting resin based on methacrylate ("Plexit M60" made by Rohm GmbH, DArmstadt, Federal Republic of Germany). To increase adhesion of PMMA resist layer 11, the surface of metal layer 12 is roughened, before
5 application of the casting resin, by sandblasting it with corundum having an average grain size of 10 μm . The resist material is irradiated with X-ray radiation generated by an electron synchrotron through a mask consisting of a solid carrier of Invar, a carrier foil of
10 a 3 μm thick titanium sheet, and absorber structures of gold with a height of 10 μm . The irradiated resist material is developed in a known manner by means of a liquid developer. The resulting relief-like microstructure 21 had a height of 500 μm . The exposed
15 regions 22 of the resist structure is filled with nickel by depositing on the metal layer 12 in a nickel sulfamate bath with 450 g/l nickel sulfamate, 40 g/l boric acid and 2.5 ml/l of a wetting agent at a bath temperature of 50°C, a pH-value of 4, and a current density of 6
20 A/dm². After circa 7 hours the resist structure was filled with nickel, and after 3 days the nickel deposit had a thickness of 5.5 mm when the metal deposition was finished. The nickel deposit was removed from the metal layer 12 by pulling, where the resist structure 21
25 remained in the nickel deposit. The rough surface of the nickel deposit which originally contacted the metal layer was planed by polish-milling. Hereafter the resist which remained in the nickel deposit was dissolved in dichloromethane. The nickel deposit attained by this
30 procedure is used as a mold insert in the following steps.

A plate of high-grade steel (material No. 1.4571) of 2 mm thickness provided with a 3 μ m thick electrodeposited copper layer and having bored holes of 200 μ m diameter in it is used as a gate plate and is pressed with the
5 coppered surface against the planed surface of the mold insert produced before. The copper layer serves as a plastically deformable seal in closing the mold insert. After evacuating this mold insert to 80 mbar the material Plexit M60 is injected into the mold insert through the
10 bored holes at room temperature. The hardened molding material was unmolded after 20 minutes by pulling the gate plate. The gate plate is used as an electrode in the next step, where nickel was deposited in the gaps of the molded form as described above. After about 11 hours the nickel
15 deposit had a thickness of 0.8 mm when the deposition was finished. Hereby, the nickel deposit, after filling the gaps of the molded form, was grown over the molded form and had covered the molded form with a 0.3 mm thick layer. The nickel deposit was machined by grinding,
20 reducing the thickness to 0.6 mm.

The electroformed part of nickel was immersed into dichloromethane to dissolve the molding polymer. The electroformed part is then etched with a solution
25 containing copper chloride and ammonia, which dissolved the copper layer on the gate plate thus releasing the electroformed part of nickel. The nickel part obtained represents the plate-shaped microstructured body 122 in Figure 12. It had the overall dimensions of 40 mm x 60 mm,

a thickness of the base plate of 100 μm , a height of the corrugated ribs 123 of 480 μm , a thickness of the corrugated ribs of 20 μm , a length of the corrugated ribs of 1.5 mm, and a distance between two ribs of 500 μm . 69
5 pieces of such plate-shaped microstructured bodies were stacked to form a catalyst carrier with overall dimensions of 40 x 40 x 60 mm and a transparency of 80%. Such a catalyst carrier can be coated with a porous layer to enlarge its surface area for example by immersion in a
10 aqueous dispersion of gamma-aluminum oxide in a known manner and then can be impregnated with an active noble metal dispersion. For scaling up this procedure to a commercial process the fabrication steps of molding and electrodeposition have to be modified in order to reduce
15 processing times and to increase the size of the manufactured parts.

The invention now being fully described, it will be apparent to one of ordinary skill in the art that many changes and modifications can be made thereto without departing from the spirit or scope of the invention as set
5 forth herein.

The present disclosure relates to the subject matter disclosed in German Application P 36 11 732.3 of April 8th, 1986, the entire specification of which is incorporated herein by reference.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:-

1. A catalyst carrier for catalytic reactions of two or more reaction partners, being formed from metal or ceramics and produced from individual plate-like microstructural bodies which are situated one above the other in layers and are aligned with one another, said bodies being combined to form a stable body and being produced by X-ray deep-etch lithography and microgalvanic moulding or by a microdeforming technique derived therefrom (LIGA method), wherein channels are formed in the stable body.
2. A catalyst carrier according to claim 1, wherein the channel walls have primary ribs protruding into the channels.
3. A catalyst carrier according to claim 2, wherein the primary ribs, in turn, are provided with ribs and/or indentations.
4. A catalyst carrier according to claim 1, wherein the corrugated ribs, which are offset relative to one another, are provided on the plate-like microstructural bodies.
5. A method of producing catalyst carriers comprising situating plate-like microstructural bodies produced by X-ray deep-etch lithography and microgalvanic moulding or by a microdeforming technique derived therefrom (LIGA method) one above the other in layers, aligning with one another and combining to form a stable body.
6. A method according to claim 5, wherein prior to being impregnated with a catalytically active substance, the plate-like microstructural bodies are coated with a material which increases the carrier surface.
7. A method according to claim 6 wherein the material which increases the carrier surface is activated alumina.
8. A method according to claim 5, wherein, during microgalvanic moulding, microstructural bodies are produced from a metal alloy or a metal containing microdispersed particles, and in that a component of the



metal alloy or of the metal is subsequently removed from the metal alloy or from the metal.

9. A method according to claim 8, wherein removal of components from the metal alloy or metal is by dissolution.

10. A method according to claim 8, wherein removal of components from the metal alloy or metal is by heating.

11. A method according to claim 5, wherein the plate-like microstructural bodies are produced by a microdeforming technique, utilising a moulding material which is formed from highly dispersed, ceramic and/or metallic components and a bonding agent, and in that the bonding agent is removed after the moulded parts have solidified.

12. A method according to claim 11, wherein removal of the bonding agent is by heating.

13. A method according to any one of claims 5 to 11, wherein, during production of the moulds for the plate-like microstructural bodies, a moulding material consisting of several components is used, and at least one of these components is removed or chemically treated prior to the formation of the microstructural body.

14. A method according to claim 5, wherein one or more microstructural bodies, having ribs provided on base plates, are wound to form a compact catalyst carrier.

DATED this 29th day of March 1990

KERNFORSCHUNGSZENTRUM
KARLSRUHE GmbH
Patent Attorneys for the
Applicant:

F.B. RICE & CO.



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Fig. 1

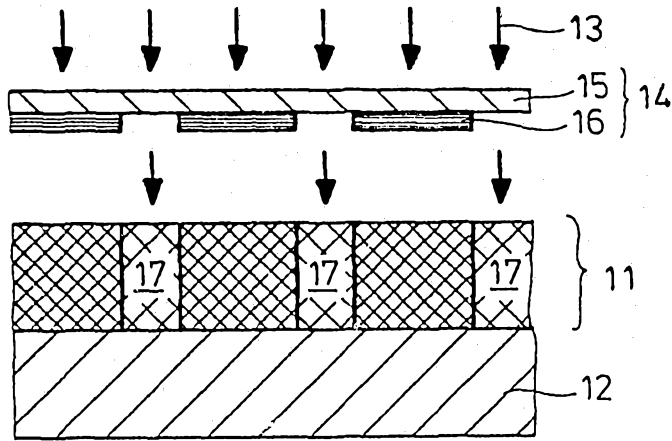


Fig. 2

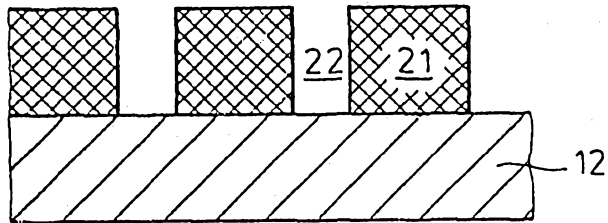


Fig. 3

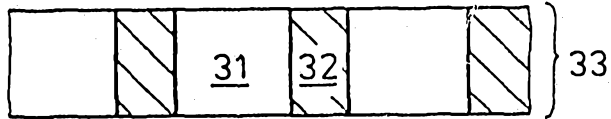


Fig. 4

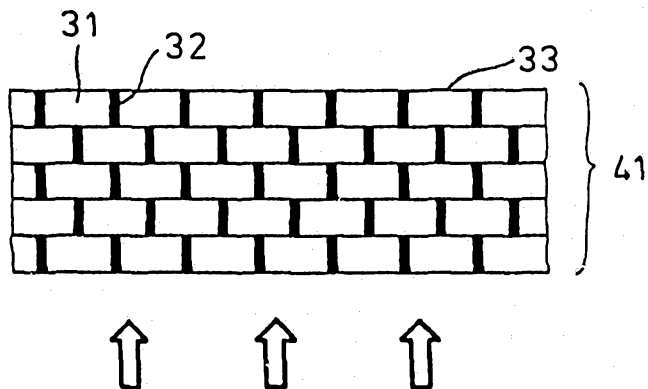


Fig. 5

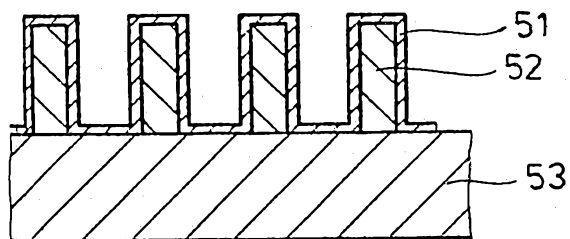


Fig. 6

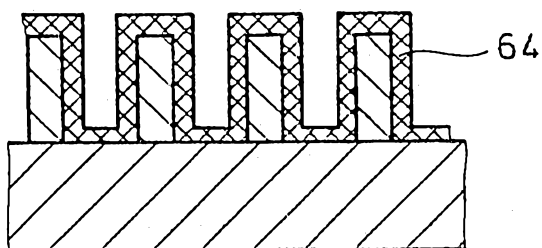


Fig. 7

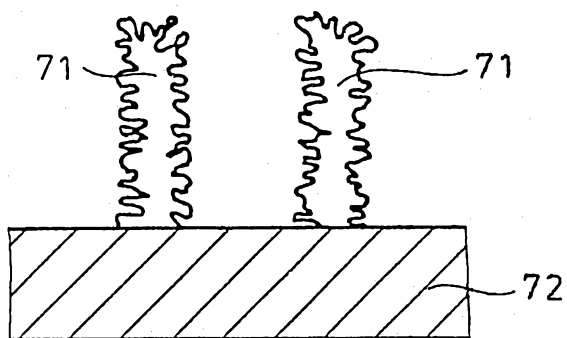


Fig. 8

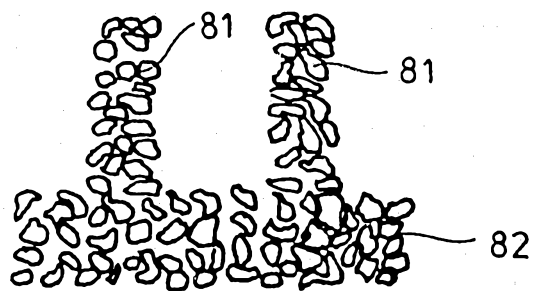


Fig. 9

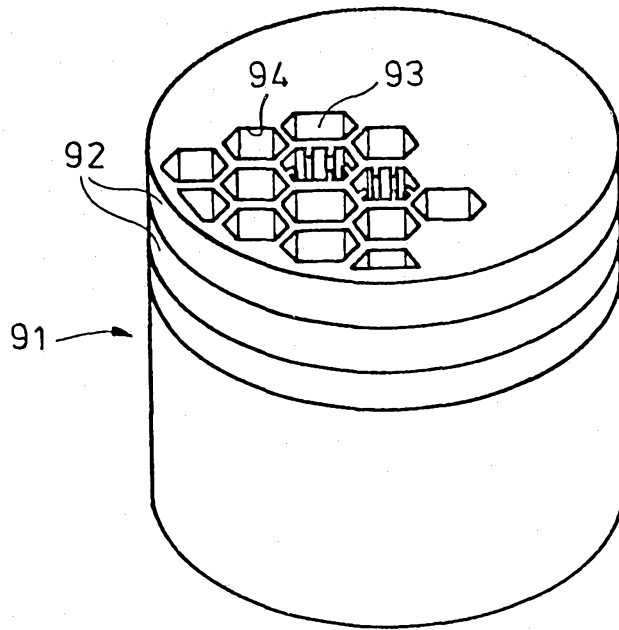


Fig. 10

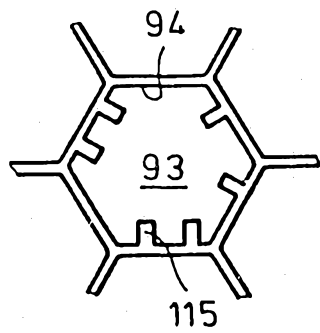
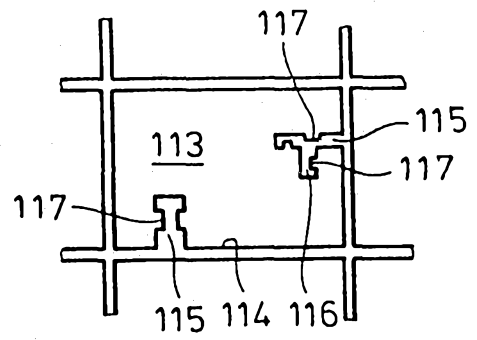


Fig. 11



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Fig. 12

