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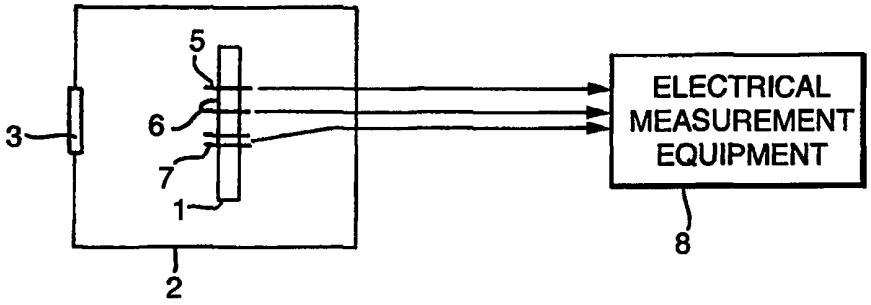
(54) Title: APPARATUS FOR THE INVESTIGATION OF SURFACE CHEMISTRY



(57) Abstract

A test piece (1) such as a sheet of metal is irradiated by a high power laser (4) in a vacuum chamber (2). The electromagnetic properties of the plasma formed at the irradiated metal surface are measured by three probes (5, 6, 7), these properties being indicative of the chemical nature of the irradiated surface.

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APPARATUS FOR THE INVESTIGATION OF SURFACE CHEMISTRY

This invention relates to apparatus for investigating the chemical composition of a surface.

It has been observed that when the surface of a test piece, a sheet of metal for example, is irradiated with a high powered laser beam, a plasma is formed in the vicinity of point of impact of the beam and metal surface. The plasma (or ionisation) results from the intense local heating of the metal surface by the laser beam.

Associated with the plasma are electric and magnetic fields, the intensities of which depend upon the surface chemistry of the test piece. Thus by measuring these fields, information regarding the chemical composition of these surface can be inferred. For instance, it is possible, from field intensity measurements to ascertain to what extent a metal surface has suffered oxidation.

Accordingly the present invention comprises apparatus for investigating the chemical composition of a surface;

the apparatus including;

a laser for irradiating the surface of a test piece and thereby initiating ionisation of a part of the surface to form a plasma,

and probe means located adjacent to said part of the surface and being responsive to the electro-magnetic properties of the plasma.

The probe means can comprise an electric field monopole having a central conductor which protrudes through an opening in the test piece.

Alternatively or additionally the probe means can be a magnetic field probe comprising a conductive loop.

As a further alternative, the probe means can be arranged to measure the conductivity of the plasma which results from the ionisation process.

Some embodiments of the invention will now be described, by way of example only, with reference to the drawings of which:

Figure 1 is a schematic diagram of apparatus for investigating the surface chemistry of a test piece,

and Figure 2 is a sectional view of the test piece of Figure 1 incorporating three different types of probe.

In Figure 1, a test piece comprising a metal sheet 1 whose surface chemistry is to be investigated, is located in an evacuated chamber 2. The chamber 2 incorporates an infra-red transmissive window 3, through which is projected

a laser beam generated by a higher power Neodynium-YAG laser 4.

The test piece is fitted with an electric field probe 5, a magnetic field probe 6 and a plasma conductivity sensor 7. The output signals from the three probes (5,6,7) are fed to electrical measurement equipment 8 located outside the chamber 2.

A description of each of the probes (5,6,7) now follows with reference to Figure 2.

The electric field probe 5 comprises an SMA connector whose central conductor 9 is pushed through a hole which is drilled through the test piece 1. The central conductor 9 is not in electrical contact with the test piece 1, but protrudes through it into the region of plasma formation. The outer conductor 10 of the SMA connector is fixed in electrical contact with the reverse side of the test piece i.e. that side remote from the surface to be irradiated. The electric field probe 5 acts as a monopole antenna, receptive to any electric field which may be generated in an ionisation process.

The magnetic field probe 6 is similar to the electric field probe 5 previously described in that it comprises an SMA connector whose central conductor 11 pushed through a

hole in the test piece yet not in direct electrical contact therewith, and whose outer conductor 12 is in electrical contact with the reverse side of the test piece. A conductor loop is formed by linking the tip of the central conductor 11 with the irradiated surface of the test piece 1 by a short piece of wire 13. Any magnetic field generated in an ionisation process and threading the loop will give rise to a current measurable by the equipment 8.

The plasma conductivity sensor 7 comprises a twinax cable whose two inner conductors 14, 15 protrude through a hole in the test piece 1 into the vicinity of plasma generation. Each conductors 14, 15 is isolated from the other and from the test piece by an epoxy plug 16. The outer conductor 17 of the twinax cable is in electrical contact with the reverse side of the test piece 1. In this example the conductor designated 14 is raised to a potential +V and the conductor designed 15 is fixed at a potential -V with respect to the outer conductor 17 and test piece 1. By measuring the current flowing through the inner conductors 14, 15, the conductivity of any plasma generated at the surface of the test piece 1 can be ascertained.

In operation, a pulse of infra-red laser radiation from the NdYAG laser 4 irradiates a point on the surface of the

test piece 1. As a result of the intense heat generated, an ionisation process occurs which results in a plasma being generated close to the surface of the test piece at the point of irradiation. The associated electric field, magnetic field and conductivity of the plasma are detected and measured by the probes 5, 6 and 7 respectively in conjunction with the electrical measurement equipment 8.

The magnitudes of the currents generated in each probe give an indication of the strength of electric and magnetic fields and of the conductivity of the plasma close to the irradiated surface. From these measurements, the chemical composition of the surface, prior to heating and ionisation can be inferred.

CLAIMS

1. Apparatus for investigating the chemical composition of a surface, the apparatus including:

a laser for irradiating the surface of a test piece and thereby initiating ionisation of a part of the surface to form a plasma,

and probe means located adjacent to said part of the surface and being responsive to the electro-magnetic properties of the plasma.

2. Apparatus according to claim 1 in which the probe means protrudes through an opening in the test piece into the vicinity of plasma formation.

3. Apparatus according to claim 2 in which the probe means comprises an electric monopole.

4. Apparatus according to claim 2 in which the probe means comprises a magnetic loop sensor.

5. Apparatus according to claim 2 in which the probe means comprises a conductivity sensor comprising a pair of conductors each with a DC voltage bias, balanced relative to the test piece, between them.

6. Apparatus according to any preceding claim in which the laser is a Neodymium YAG laser.

7. Apparatus according to any preceding claim in which the test piece and probes are enclosed in a vacuum chamber.

8. Apparatus for investigating the chemical composition of a surface substantially as hereinbefore described with reference to the drawings.

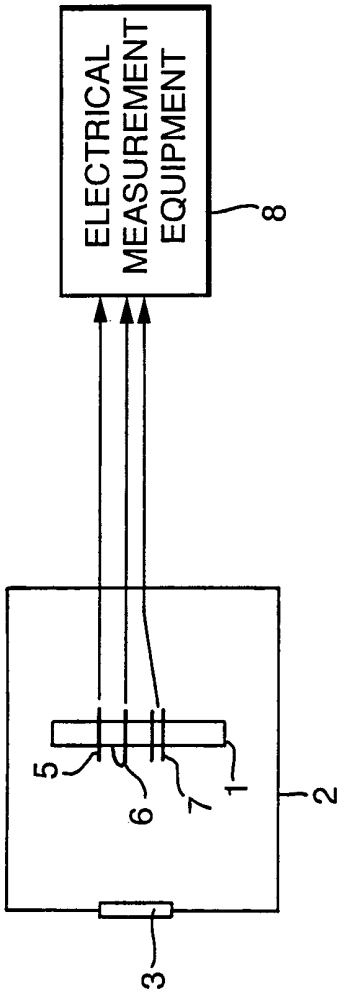
ELECTRICAL MEASUREMENT EQUIPMENT
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Fig.1.

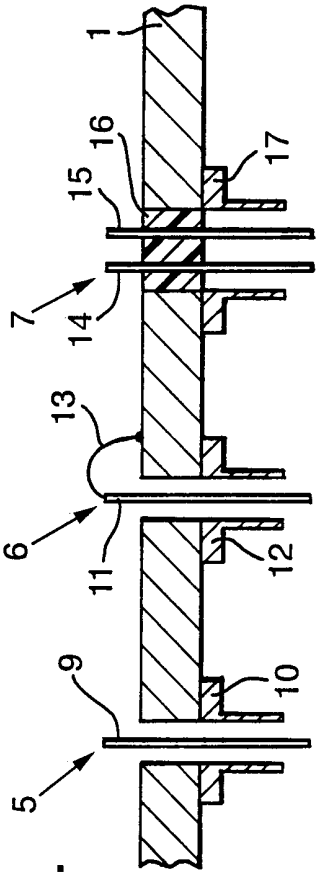
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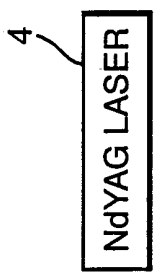
Fig.2.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NdYAG LASER

INTERNATIONAL SEARCH REPORT

Internat. al Application No
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A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H05H1/00 G01N21/17

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)
IPC 6 G01N

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)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	J. BRCKA ET AL: "Investigation of plasma expansion in the PLD process by means of an electrical probe" PLASMA SOURCES, SCIENCE AND TECHNOLOGY, vol. 3, no. 2, May 1994 (1994-05), pages 128-133, XP002110403 Bristol, GB	1,6,7
A	page 128, right-hand column, line 5 - page 129, left-hand column, line 2 page 129, right-hand column, line 15 - page 130, left-hand column, line 12 figures 1,4	3
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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
27 July 1999	10/08/1999

Name and mailing address of the ISA	Authorized officer
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2

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INTERNATIONAL SEARCH REPORT

Internat. al Application No
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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2

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