Component fabrication and in particular fabrication by deposition processes for large components is made more convenient by initially depositing a masking deposition layer (2) upon a thin substrate (1) such that subsequently shaped metal deposition techniques can be used. Previously, the relatively thin nature of the substrate (1) has rendered the hot heat plume (11) of the shaped metal deposition technique too intrusive. It will be understood that this heat plume (11) may distort the thin substrate (1). By initial application of a protective masking deposition layer (2), the underlying substrate is protected by that layer (2) from the heat plume (11) generated by the shaped metal deposition process.
Component Fabrication

The present invention relates to component fabrication and more particularly to fabrication of relatively large components by deposition techniques.

Deposition techniques are utilised in order to form an approximate shape of a finished component or article by deposition of a powder or wire raw material upon a substrate. The principal deposition techniques are shaped metal deposition (SMD) and direct laser deposition (DLD). In either event, the raw material as indicated is in the form of a powder or wire which is rendered molten in order that through successive depositions, one upon the other, a particular component shape can be built to approximate the final component. Clearly, there is normally a final finishing stage where surface shaping and other features such as screw threads are formed in the component.

These deposition techniques have particular advantage where the base material is expensive and so machining processes from a solid stock body can be wasteful in terms of material loss. With a deposition technique a fabricated or hybrid route is followed where the shape of the finished component is built up from either powder or wire raw material, and then only the final machining process is performed.

SMD and DLD processes combine welding technology with computer aided design/computer aided manufacture systems to offer alternatives to current manufacturing technologies. Particular benefits relate to reducing the amount of production tooling required for prototypes, reducing component inventory through use of standard welding wire or powder metallic material as the basis for additive deposition, reduction in component lead time, design
flexibility and provide an alternative to casting or forging where such processes may introduce structural problems within the component.

Generally, SMD depositions are more rapid allowing quicker manufacture of the approximate or net component shape, whilst DLD is a slower deposition process. Thus, SMD is more favourable for manufacture of large components but it has a significant disadvantage in that it cannot be applied with respect to relatively thin substrate, that is to say less than 10mm thick. The SMD process incorporates a relatively high temperature and creates a thermal plume as it is deposited. This thermal plume will extend into the thin substrate from which the SMD deposition extends. Such a high temperature thermal plume will cause thermal distortion in the substrate and so possible failure of that substrate.

The DLD process, by use of a laser in order to create the deposition rather than a TIG or MIG welding process as with the SMD process utilises a far lower heat energy. In such circumstances there is less heat plume which can cause distortion of the base substrate from which the deposition process extends. Unfortunately the metal deposition rates of normal DLD systems is significantly lower than acceptable. Typically, a DLD system will achieve a deposition rate of only 50 grams of material per hour whilst an SMD system may achieve 500 grams per hour. In such circumstances, it will be appreciated that DLD systems are inappropriate for manufacture of large structural sections such as those of a compressor casing for a gas turbine engine. Nevertheless, as indicated previously, the unacceptably severe thermal distortion effects of the SMD is unacceptable, whilst the low deposition rates of DLD render both approaches unacceptable for large components which have a thin substrate base.
In accordance with the present invention there is provided a method of component fabrication comprising the steps of forming a masking deposition layer by direct laser deposition upon a substrate, adding a structural deposition layer by a shaped metal deposition to the masking deposition layer to form a component shape, the masking deposition layer being formed to a depth sufficient to mask a heat plume from the shaped metal deposition layer.

Generally, the method includes forming the deposition layer of sufficient thickness to ensure a shaped metal deposition process does not significantly thermally distort the substrate whereby that substrate is damaged.

Additionally, the substrate and masking deposition layer form a stable platform for subsequent shaped metal deposition processes.

Additionally, in accordance with the present invention there is provided a component fabrication intermediary comprising a substrate and a masking deposition layer formed by direct laser deposition, the masking deposition layer of sufficient depth to form a platform upon which shaped metal deposition processes can be performed without detrimental distortion of the substrate.

An embodiment of the present invention will now be described by way of example only with reference to the accompanying drawing illustrating a schematic cross section of a component fabrication in which;

Fig. 1a illustrates direct laser deposition

Fig. 1b illustrates a masking deposition layer upon a substrate and;

Fig. 1c illustrates addition of a structural layer by shaped metal deposition.

The processes of shaped metal deposition (SMD) and direct laser deposition (DLD) are well known and generally involve presentation of a raw material such that it will be
rendered molten to allow deposition either through an electrical arc in the shaped metal deposition process or through exposure to a laser beam in the direct laser deposition process. The reader is directed to relevant text books and other disclosures with regard to the inherent processes of shaped metal deposition and direct laser deposition techniques but these will be readily understood by those skilled in the technology.

A substrate is utilised in order to provide an initial structural frame upon which deposition can be performed. It will be understood that when forming such structures as tubes or compression rings, it is convenient to provide a thin walled tube or ring upon which the deposition process is initially performed. This thin walled substrate may itself remain a part of the component once formed or be machined or otherwise processed/removed from the component as required. In either event the substrate will be relatively thin and generally be no thicker than 10 millimetres. In such circumstances any distortion or cracking of the substrate may render the eventual component unacceptable.

The shaped metal deposition process as indicated involves creation of an arc consistent with TIG or MIG welding techniques in order that the raw material is rendered molten and a deposition layer laid down upon each pass. In such circumstances, each pass of the shaped metal deposition process will build up in order to form the component structure which as indicated may subsequently be machined or otherwise processed into a final form. Nevertheless the shaped metal deposition process does create a hot heat plume which will penetrate any substrate. If that substrate is thin as described above the thermal distortive effects of the heat plume may damage the substrate and therefore eventual component formed.
Fig. 1a illustrates a thin substrate 1 upon which a masking deposition layer 2 is formed by a direct laser deposition process. This direct laser deposition process involves presentation of a powder or wire 3 to the surface of the substrate 1 such that a directly applied laser beam 4 melts the powder or wire 3 into a molten state whereby it becomes fused with the substrate 1 as well as creates the masking deposition layer 2.

As indicated above, the direct laser deposition process is relatively slow with deposition rates of only 50 grams per hour. In such circumstances the masking deposition layer 2 is relatively thin. Furthermore, this low deposition rate for direct laser deposition would not be commercially viable in order to form large component structures such as compressor rings for a gas turbine engine.

Fig. 1b illustrates an expanded cross-section in the direction A-A depicted in Fig. 1a when the direct laser deposition process is completed in accordance with the method of the present invention. Thus, as can be seen the component pre cursor or intermediary formed as a combination of the substrate 1 and masking deposition layer 2 is a relatively stable platform in which the depth of the masking deposition layer acts as a protection for the substrate 1. As can be seen, generally the masking deposition layer 2 is thicker than the underlying substrate 1. However, the actual thickness of the masking deposition layer 2 will depend upon the heat characteristics of the material from which the masking deposition layer 2 is formed. It will be understood that this masking deposition layer 2 is essentially used in order to protect the substrate 1 from a heat plume as a result of the shaped metal deposition process subsequently applied to the platform comprising the substrate 1 and layer 2. In such
circumstances depending upon the heat characteristics of
the material from which the layer 2 is formed, the
thickness of that layer may be varied to provide a
convenient and viable balance between adequate depth for
protection against the shaped metal deposition process heat
plume against the time consideration of the limited direct
laser deposition rate. In such circumstances the depth of
the masked deposition layer 2 will depend upon knowledge of
the subsequent shaped metal deposition process in terms of
heat energy and heat plume characteristics.

Fig. 1c illustrates an expanded cross-section
illustrating application of further material by shaped
metal deposition technique upon the component pre cursor or
intermediary formed by the substrate 1 and masking
deposition layer 2 described with regard to Fig. 1a and
Fig. 1b. Thus, as can be seen, a wire 5 is presented such
that through an electrode 5 an electrical arc 7 is created
such that molten material 8 is deposited to build up the
walls or other parts of a component. As can be seen, by
successive passes, illustrated by broken lines 9 the shaped
metal deposition process is additive in order to form the
structural wall 10 of the component.

Of particular concern with regard to the present
invention is the presence of a heat plume 11 which extends
into the already cooling layers of the component wall 10 to
da depth 12 below a surface 13 of the most recently
deposited layer of shaped metal deposition. This heat
plume acts to at least partially re-melt the material of
those layers such that there is fusion between the newly
molten wire 5 caused by the arc 7 in order to create
further deposition 14 upon the component wall 10. It is
this heat plume which if the shaped metal deposition
technique were applied directly to the substrate 1 would
cause thermal distortion and therefore damage to that substrate 1.

In order to protect the substrate 1, the direct laser deposition process, as indicated above applies a masking deposition thereto. Thus, this masking deposition layer 2 must have sufficient depth that the heat plume 11 does not significantly affect the substrate 1 in order to create detrimental damage or distortion to that substrate 1. Clearly, the shape and depth 12 of the plume 11 may vary due to a number of factors including the intensity of the arc 7, type of material deposited and heat transfer characteristics. Nevertheless, by a combination of the relatively cool direct laser deposition process in order to provide the masking deposition thereto with the hotter but more rapid deposition rate of the shaped metal deposition process, it will be understood that large components can be more conveniently formed.

Generally, the depth of the masking deposition layer 2 will be chosen such that there is a degree of margin for error whereby the heat plume 11 does not detrimentally impinge upon the underlying substrate 1 for all foreseeable situations. Thus, it will be understood that in the course of shaped metal deposition there may be parts of the component wall 11 which require either greater width of deposition or at which there is linger of the electrode 6 and wire 5 in order to create a structural feature whereby the heat plume 11 may increase in size in comparison with the usual depth 12. In such circumstances the masking deposition layer 2 should similarly be configured such that the heat plume 11, even though of increased depth 12 does not impinge upon the substrate 1.

The direct laser deposition process in providing the masking deposition layer 2 creates a structurally stable platform with the substrate 1. This platform is a
component pre cursor or intermediary for the subsequent major deposition processes performed by the shaped metal deposition process as described above. In such circumstances the minimal heat input attributable to the direct laser deposition process acts to minimise distortion of the substrate 1 in creating the structurally stable platform to act as a component pre cursor. Generally the direct laser deposition technique can be employed utilising coaxial or external power feed with an optic fibre directing a laser beam 4 from a YAG, diode or CO₂ laser source.

As indicated, the shaped metal deposition process, whether it utilises TIG or MIG welding techniques or not, is employed to complete the deposition in order to form a component structure which can then be finally machined to shape. The effects of thermal distortion caused by shaped metal deposition is minimised due to the protective effect of the masking deposition layer 2 upon the structurally stable platform comprising that layer 2 and the substrate 1. In such circumstances, as indicated previously, the direct laser deposition process must create a masking deposition layer which is of sufficient thickness, depth and volume to prevent thermal distortion of the original thin walled substrate 1.

By a combination of the direct laser deposition and shaped metal deposition processes as indicated above it is more convenient to manufacture large components by deposition techniques.
CLAIMS

1. A method of component fabrication comprising the steps of forming a masking deposition layer (2) by direct laser deposition upon a substrate (1) adding a structural deposition layer (9) by shaped metal deposition to the masking deposition layer (2) to form a component shape (10), the masking deposition layer (2) being formed to a depth sufficient to mask a heat plume (11) from the shaped metal deposition layer (9).

2. A method as claimed in claim 1 wherein the masking deposition layer (2) is of sufficient thickness to ensure a shaped metal deposition process does not significantly thermally distort the substrate (1) whereby that substrate (1) is damaged.

3. A method as claimed in claim 1 or claim 2 wherein the substrate (1) and the masking deposition layer (2) form a stable platform for subsequent shaped metal deposition processes.

4. A component fabrication intermediary comprising a substrate (1) and a masking deposition layer (2) formed by direct laser deposition, the masking deposition layer (2) being of sufficient depth to form a platform upon which a shaped metal deposition process is performed without detrimental distortion of the substrate (1).

5. A turbine engine component incorporating a component fabricated according to the method of any of claims 1 to 4.

6. A turbine engine component formed utilising a component fabrication intermediary as claimed in claim 4.
Fig. 1(a)

Fig. 1(b)

Fig. 1(c)
**PATENT COOPERATION TREATY**

**PCT**

**INTERNATIONAL SEARCH REPORT**

(PCT Article 18 and Rules 43 and 44)

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**Applicant**

ROLLS-ROYCE PLC

This international search report has been prepared by the International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 4 sheets.

It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**
   a. With regard to the language, the international search was carried out on the basis of:
      - [ ] the international application in the language in which it was filed
      - [ ] a translation of the international application into , which is the language of a translation furnished for the purposes of international search (Rules 12.1(a) and 12.1(b))
   b. [ ] With regard to any nucleotide and/or amino acid sequence disclosed in the international application, see Box No. I.

2. [ ] Certain claims were found unsearchable (See Box No. II)

3. [ ] Unity of invention is lacking (see Box No III)

4. With regard to the title,
   - [ ] the text is approved as submitted by the applicant:
   - [ ] the text has been established by this Authority to read as follows:

5. With regard to the abstract,
   - [ ] the text is approved as submitted by the applicant
   - [ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority

6. With regard to the drawings,
   a. the figure of the drawings to be published with the abstract is Figure No. 1c
      - [ ] as suggested by the applicant
      - [ ] as selected by this Authority, because the applicant failed to suggest a figure
      - [ ] as selected by this Authority, because this figure better characterizes the invention
   b. [ ] none of the figures is to be published with the abstract

Form PCT/ISA/210 (first sheet) (April 2005)
# INTERNATIONAL SEARCH REPORT

**International application No**
PCT/GB2006/001280

### A. CLASSIFICATION OF SUBJECT MATTER

INV. B22F3/105  B23K28/02  C23C4/02  C23C26/02

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)
B22F  B23K  C23C

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

Electronic database consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, PAJ, CHEM ABS Data, WPI Data

### C. DOCUMENTS CONSIDERED TO BE RELEVANT

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* Special categories of cited documents:

  *A* document defining the general state of the art which is not considered to be of particular relevance.
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Date of the actual completion of the international search: 14 June 2006

Date of mailing of the international search report: 21/06/2006

Name and mailing address of the ISA/ European Patent Office, P. B. 6616 Benjamin Franklin NL - 2280 HJ Hilversum
Tel: (31-70) 340-2040, Tx: 01651 epo nl, Fax: 01651 340-3216

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