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METALLURGY DEPARTMENT

# PRECISION MACHINING AND MICROSAMPLING
## in the Irradiated Fuel Research Laboratory (Saclay)
## and the Processing and Radiometallurgy Department (Grenoble)

by

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## Abstract

Techniques for the precision machining and microsampling of cladding and fuel materials are gradually being developed in our two laboratories. Various kinds of equipment are required for the work and depend on the investigation concerned, the desired precision and the nature of the material to be machined.

The authors describe the methods used and the results obtained on irradiated materials in their laboratories.

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## I. INTRODUCTION

Techniques of precision machining and microsampling on cladding materials and fuel materials are gradually being developed in our two laboratories.

The objectives are:

I.1 To obtain small quantities of irradiated materials for work in glove boxes or on poorly shielded equipment, e.g.,

a) Making thin foils and cores on fuel element cans for Pu diffusion studies,
b) Making thin foils on fuel elements (can, fuels) for analyses on a shielded microprobe.

I.2 Machining at specific points of an irradiated material to an inclusion or a series of low-diameter ($<1$ mm) cores, e.g.,

a) Sampling one of a number of metallic inclusions in uranium oxide subjected to high-power irradiation at burnups of more than 1000 MWd/t U. The diameters of the inclusions vary from a few microns to several hundred microns,
b) Establishing radial distribution graphs for each fission product ($\gamma$ emitter) as a function of the irradiated fuel power conditions.

For the latter purpose the samples used to determine the quantities of residual fission gas in the $UO_2$ matrix can be included.

## II. METHODS

The methods used for precision machining and microsampling vary with the type of examination concerned, the precision desired and the nature of the material to be machined. To solve the problems presented to us, we therefore used the following equipment.

a) Sensitive punch,
b) Slow shearing device,
c) Laser,
d) Ultrasonic punch.

The tool used is a standard Norton grinder (ref. 37 C 180 P8B, ID 180, thickness 1 mm, bore 25.4). The lubricant is either cutting oil or Lubrisurfex. Owing to the presence of Na and NaK in the cells, water cannot be used.

IV.2 To obtain thin foils from stainless steel clad $UO_2$ fuel elements.

The minimum thickness achieved is 0.5 mm. Below that, the foil deforms and is difficult to polish prior to examination on the micro-probe.

This result is achieved using a standard Norton diamond grinder (ref. FEV - 155 LO, ID 150, specification Di 005 R 7576x13) and specially preparing the specimen for sampling.

Preparation consists of surrounding the specimen with a plexiglass cylinder and then carrying out coating and impregnation in a vacuum (Fig. 3).

The coating prevents burring on the foil on completion of cutting, while impregnation ensures the bonding of all the irradiated fuel fractions.

## V. MICRO-EVAPORATION BY LASER

### V.1 Method (Fig. 4)

The polished and etched specimen is placed in a vessel of which the atmosphere can be controlled or even evacuated. A quartz window serves both for the passage of the laser beam and for observing the polished surface by means of an optical system in the same alignment; inversion is by means of a tilted prism.

The laser used is a ruby laser of wavelength 6943 Å with a maximum power of 1 joule. The projection time is of the order of 2-5 m/s.

A glass plate 0.15 mm thick placed 0.5 - 1.0 mm away covers the object and ensures recovery of fission products.

V.3 Discussion

Standard equipment fitted with a lens with fairly long focus was used for the projections. It was therefore difficult to reduce the crater diameters in order to confine the sample to one inclusion.

However, by reducing the focus it was possible to reduce the crater diameters by 20-50 $\mu$.

It will readily be seen from the above table that the proportions condensed on the $Ce^{144}$ and $Cs^{137}$ targets differ; also, although there is no $Ru^{106}$ on the targets, there is a large amount at the crater edges.

Vaporization and condensation of the $UO_2$ matrix are selective. Certain fission products such as ruthenium are not recovered; the atmosphere in the vessel (pressure and oxygen) is definitely important.

It is to be noted that a recent study by Adams reaches the same conclusions.

## VI. MICROSAMPLING BY ULTRASONIC MACHINING

The principle of sampling by ultrasonic coring has been described in a previous publication and applied to the determination of fission gases in irradiated uranium dioxide.

It will be remembered that the punch has a power of 120 W HF and a frequency of 20,000 c/s. It is fitted with a carriage enabling the specimen to be presented either under the sampling tool or under an optical system (x 10) with a reticle (Figs. 5 and 6).

The specimen is mounted on a table X, Y and is positioned with an accuracy within 0.1 mm.

Three types of sample can be obtained.

V.1 Core with ID 1-4 mm (Fig. 7)

The tool is semi-hard steel 0.25 mm thick. Rubbing with an abrasive is not necessary; a few drops of water with an abrasive powder in suspension are sufficient. Fuel is also recovered ultrasonically.

Fig. 1 Conicity $1^{o}$
Conicity 0.2
Pu diff. Cladding samplings

Fig. 2 Abrasive shearing device

1. Motor
2. Saw shaft
3. Saw
4. Moving vice
5. Counterweight
6. Vice tightener
7. Tank
8. Tank lifting device
9. Transverse vice carriage
10. Automatic arm holder

Fig. 3 Direction of cutting
Stainless cladding
Cuts
Precision machining

Fig. 4 eyepiece
laser crystal
lens
target
quartz window
vacuum
Diagram of laser beam device

Fig. 5 eyepiece (x 10)
ultrasonic machine
specimen
tool-holder
tool
Retractable device with counterdrive for dismantling tool-holder

Fig. 6 US machine stand
magnetic bearing
travel 200
window and machine axis
eyepiece axis
Mandrel carriage free on skids for rapid changeover from "reading" position, after choice of coordinates, to "working" position.

Fig. 7 ULTRASONIC CORING - TYPES OF TOOL-HOLDERS AND TOOLS
coring 0.3 mm
coring 1.5 to 4 mm
crown coring
calibrated split grip
mimi-tube of ID 0.4 reduced to ID 0.3 over 3mm