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NUCLEAR TRANSMUTATION IN DEUTERED PD FILMS IRRADIATED BY AN UV LASER

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ABSTRACT

Nuclear transmutation results in palladium films loaded with deuterium gas and processed by an excimer laser are reported. Vacuum evaporation was utilised to obtain palladium films on Si wafers. The films were inserted in chambers with deuterium gas at a variable pressure up to 5 bar. During the UV laser processing the maximum irradiating energy density was lower than 50 mJ/cm in order to avoid the ablation of the palladium films. The samples were analysed by a scanning electron microscope and an electron probe microanalyzer. After the experiments, we found that the Pd films was modified. They presented many cracks and bubbles with very sharp edges. In the bubbles the transmutation of elements was observed.

INTRODUCTION

In the past, experiments were performed in Applied Electronics Laboratory of Lecce University devoted to investigate the "cold fusion" phenomenon as a potential new energy source [l]. Later on, we concentrated our attention upon nuclei transmutation which seemed to be either a reproducible phenomenon or an interesting result of nuclear physics.

Several "cold fusion" experimental results have reported the generation of new elements by Pd nuclei transmutation utilizing Pd samples as bulk and films [2-5]. The elements found out by the EDX microanalysis on the samples used in the first experiments were at first attributed to contamination, as no particular care had been made for the samples preparation before putting them inside the chambers. In this work, in order to exclude the contamination and to study the effect of the transmutation, the chambers have been accurately prepared and the samples were obtained by evaporating palladium on Si wafers. In this way, depositing Pd film of different thickness, we wanted to study the transmutation of elements as a function of the Pd film thickness and of the D_2 pressure. Gas loading was also accurately carried out in order to reduce contamination. Measurements of X and gamma emission and other particles have been also performed by other authors [6, 7].

We studied also the transmutation of elements versus the Pd film thickness and the D_2 pressure applied during the loading process. The maximum new element density was found on the film of greatest thickness.

EXPERIMENTAL APPARATUS

We realized the films by thermal evaporation of palladium wire (99.95% purity) from a W boat on Si (100) wafers as substrate. The evaporating chamber was evacuated by a diffusion pump up to a residual pressure below $1 \cdot 10^{-5}$ Pa. At about 1 cm below the substrates a sliding mask was placed. In this way, during the deposition the mask was moved in order to deposit films of three different thickness in the same deposition run. The substrates were cut and their area was about 1 cm. They were cleaned by an ultrasonic bath in acetone.

The reaction chambers were stainless steel cylinders having an internal diameter of 4 cm and a length of 20 cm. Before performing the experiments, the chambers were accurately washed with acetone and fluxed with nitrogen. Two quartz windows were placed at the two extremities of each chamber to allow the inside access for the UV laser beam. They were evacuated by means of a turbomolecular vacuum pump and filled with deuterium from gas bottles. Laser processing was performed after injecting D_2 gas inside the chamber.

The laser utilized was a home made XeCl excimer laser (λ= 308 nm) [8]. The UV light favors multiphoton

absorption processes, which localize the gas atoms within the Pd host crystal [9]. The laser beam was led into the chamber after the D_2 loading process by a focalizing lens (L) and a set of neutral density filters. The experimental apparatus is shown in Fig. 1. The laser energy density was varied by changing the lens position and the neutral density filter.

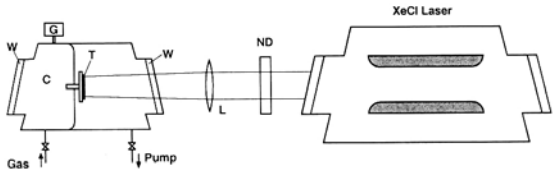

Fig.l: Experimental setup for laser irradiation. C: Loading chamber; ND: Neutral density filters; T: Target, W: windows; G: Pressure Gauge.

EXPERIMENTAL RESULTS AND DISCUSSION

Utilizing the evaporating device described above, we produced Pd films of 16, 35, 50, 83, 90, 106, 125 and 141nm on silicon wafers. The thickness was measured by a Tencor Alpha Step 200 stylus profilometer with an accuracy of about 5%. One or two samples were placed inside of each chamber, where the pressure of the deuterium was raised to 2.4 or 5 bar. After one week of D_2 loading some samples were irradiated with laser in order to create layers and to localize the gas atoms inside the palladium. Laser fluence was very low to avoid palladium ablation. Thicker films were irradiated with 50 mJ/cm^2, while lower energy densities were applied to Pd films having a lower thickness. The irradiation consisted in 400 shots at a laser repetition rate of 1 Hz and the process was repeated 4 times weekly. The total laser shots applied were 1600.

A few samples were closed in a chamber and taken into contact with air.

After about 5 weeks the chambers were open and the samples were analyzed by a scanning electron microscope (SEM) and by an Energy Dispersive X ray Spectroscopy (EDX) for studying the surface morphological aspect and the chemical composition. All samples processed with D_2 shown many cracks and bubbles with very sharp edges while the samples taken into contact with air did not present any morphological modification. This points out that the D_2 concentration is the cause of the morphological modification.

The cracks found were distributed over the whole area and the distance among the bubbles, whose external dimensions were about 2 μm, increased as the film thickness increased. Generally the bubbles were created near to the cracks, see Fig. 2. This result indicates that the formation of the bubbles is tied to the formation of the cracks. The EDX spectrum recorded on the bubble presented many new elements: Sn, Ag, Na, Mg, S, Cl, K, Fe, Ni, Zn, Al, P, Ca, La, Ce, Cr, Ga, F, Ti and Cu. Considering only the elements having a concentration higher than 5% we plotted the number of elements found as a function of the Pd thickness, as Fig. 3 shows. One can see that the number of elements increases as the film thickness increases. There are four films showing a big number of elements (Table 1) and the maximum was obtained with the sample loaded with 2.4 bar and without laser action (case A) and with the sample loaded with 5 bar and processed with laser beam (case D).

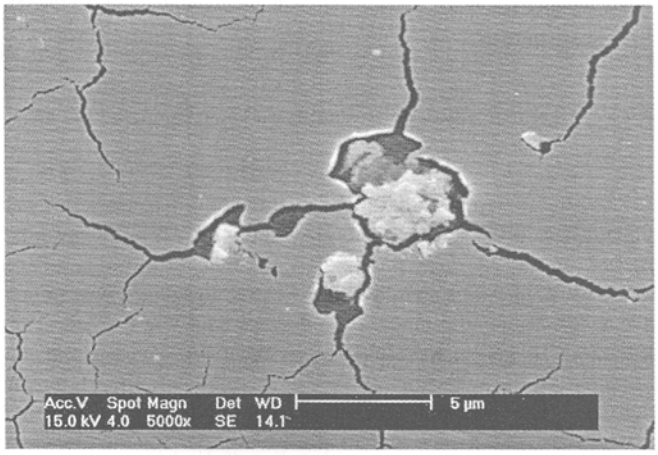

Fig. 2: SEM micrograph of a modified Pd film.

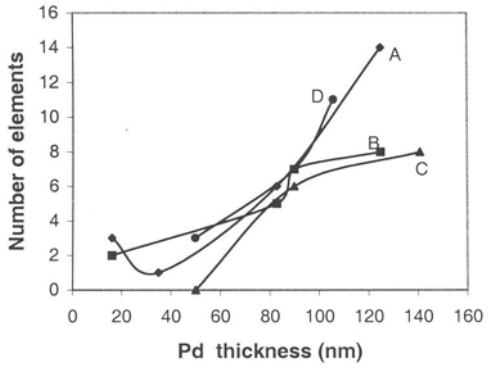

Fig. 3: New element number as a function of the Pd film thickness loaded with palladium. A) sample loaded with 2.4 bar; B) sample loaded with 2.4 bar and processed with laser, C) sample loaded with 5 bar and D) sample loaded with 5 bar and processed with laser.

	Film thickness	**D_2 pressure**	**New elements**
Case A no laser action	125 nm	2.4 bar	Fe, Ni, Zn, Na, Mg, Al, P, S, Ca, Cl, K, La, Ce, Cr.
Case B laser action	125 nm	2.4 bar	Na, Mg, Al, P, S, Cl, Ca, Ga.
Case C no laser action	141 nm	5.0 bar	Na; Al, S, Cl, K, Ca, Fe, Ga.
Case D laser action	106 nm	5.0 bar	Na, Al, S, Cl, K, Ca, Fe, Ni, Zn, Cu, Sn.

Table 1. Global results related to A, B, C and D cases.

It is possible to suppose that these results are due to nuclear transmutations and they could be provoked by phonons and plasmons generated inside the crystal [10,11]. In the A case the deuterium concentration is low and it can induce low energy phonons, while in the D case the deuterium concentration is high and as a consequence high energy phonons could be formed. These last two conditions allow to get many elements in the film. Fig. 4a and 4d show the element concentration on atomic number of the elements found on sample A and D, respectively. The elements found are centered at 15, 28 and 58 atomic number for A case and 20, 28 and 50 atomic number for the D case. These two cases present a high element concentration. Fig. 4b and 4c show the element concentration on atomic number of the elements found on sample B and C, respectively. The elements found are centered at 13, 20 and 31 atomic number for B case and 11, 17, 20 and 26 atomic number for the C case.

These last two cases present a low concentration likely due to a lower phonon and plasmon energy the low deuterium loading.

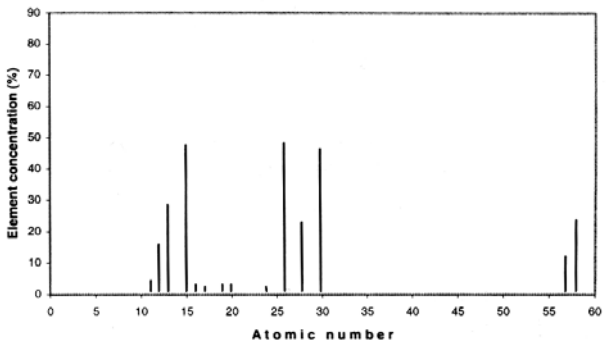

Fig. 4a: Plot of the percentage of the elements found in the bubbles as a function of the atomic number. Data related to A case.

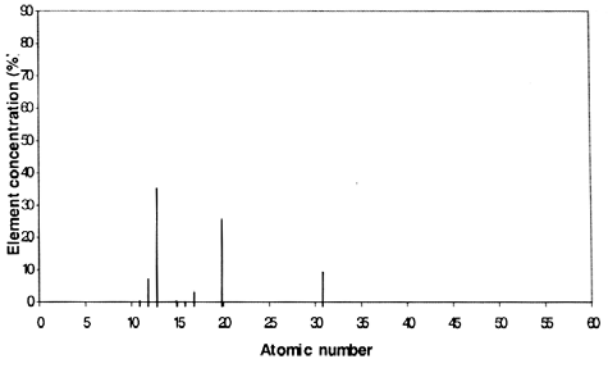

Fig. 4b: Plot of the percentage of the elements found in the bubbles as a function of the atomic number. Data related to B case.

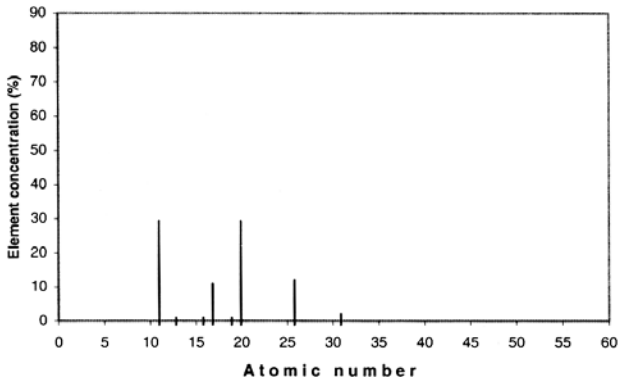

Fig. 4c: Plot of the percentage of the elements found in the bubbles as a function of the atomic number. Data related to C case.

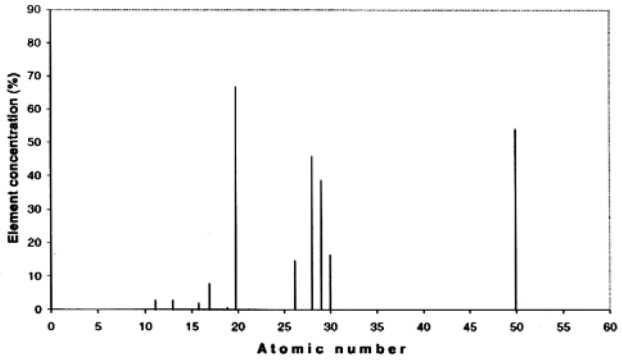

Fig. 4d: Plot of the percentage of the elements found in the bubbles as a function of the atomic number. Data related to D case.

We performed measurements on Pd films taken into contact with air. These samples did not present transmutation of elements and the surface conductivity was lower than the one of the film loaded with deuterium.

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