

palladium-zirconium alloys by ball milling (6). In these experiments a range of palladium-zirconium alloys were prepared by arc melting the constituents together, then crushing and milling the ingot. Milling was carried out under argon to prevent oxidation. The products of the milling process were examined by X-ray diffraction which showed that single phase amorphous  $\text{Pd}_x\text{Zr}_{100-x}$  alloys were obtained, for  $x > 45$ . The upper limit for  $x$  was certainly greater than 60. For  $x < 45$  a two phase material consisting of an amorphous phase and  $\text{PdZr}_2$  intermetallic was formed.

In a further publication the same group of investigators considered the amorphisation of platinum-zirconium alloys by a high-energy ball milling process. Using X-ray diffraction and differential thermal analysis, they established the feasibility of amorphising  $\text{Pt}_{33}\text{Zr}_{67}$  and  $\text{Pt}_{50}\text{Zr}_{50}$  alloys by ball milling for about 270 hours, under an argon atmosphere (7).

Studies of the palladium/platinum-zirconium system represent an extreme test of the current models describing solid state amorphisation by ball milling (8). Palladium and platinum display the largest heats of mixing, and therefore form with zirconium the most stable intermetallic compounds. Despite the stability of the crystalline phases the ball milling process is still able to produce the metastable glassy state.

### Future Work

The dimensions of amorphous materials which can be produced by the melt spinning route are limited by the need for extremely rapid quenching. Solid state amorphisation by diffusion from thin layers is similarly constrained by the thickness of a single amorphous layer, but it is possible to use a composite structure to produce a bulk glassy material. In the same way, solid state amorphisation by ball milling offers the possibility of producing bulk glassy alloys by an industrial scale process. The unusually high exothermic alloying reactions of the platinum group metals, with a range of other elements, and their correspondingly stable intermetallic compounds, do not in any way preclude their participation in such amorphisation reactions. In fact, the high

negative heat of mixing of a variety of metals with the platinum group metals appears to favour solid state amorphisation reactions, and is likely to ensure the inclusion of the platinum group metals in future work in this area. M.L.D.

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## Palladium in a Thin-Film Hydrogen Sensor

There is a growing interest in the development of solid state devices for use as chemical sensors, and following the significant progress made in hydrogenated amorphous silicon thin-film transistor technology, the possibility of using devices based upon this as sensors has become very attractive.

A recent letter from the Istituto di Elettronica dello Stato Solido, CNR, Italy, describes the development of a palladium-gate thin-film transistor as a hydrogen sensor (L. Mariucci, A. Pecora, C. Puglia, C. Reita, G. Petrocco and G. Fortunato, *Jpn. J. Appl. Phys., Part 2 Lett.*, 1990, **29**, (12), L2357-L2359).

Although the electrical characteristics of a top-gate device are inferior to those of a bottom-gate one, the former was selected to meet the requirement of a gate electrode in direct contact with the environment. A 100 nm thick layer of palladium was sputter deposited onto the 9 nm thick silicon nitride employed as the gate insulator. This enables the device to respond in a relatively fast time and in a relatively stable and reproducible manner to hydrogen, and the investigation has shown that such devices are good enough for application as hydrogen sensors.