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Platinum Deposition on Sapphire and Alumina

SPUTTERED SUBSTRATES FOR FERROELECTRIC FILMS IN COMPUTER MEMORIES

An important factor in the successful development of sputtered thin ferroelectric films for computer memories is the availability of a substrate that is smooth, electrically conductive, refractory, and inert. Platinum films sputtered on to polished sapphire or smooth alumina chips meet this requirement but there is a problem of adhesion between the noble metal film and the oxide ceramic. Even chromium and titanium, which are often used as interface layers to promote adhesion, oxidise under the platinum during the prolonged heat treatment that converts dielectric to ferroelectric films at 950°C in a corrosive atmosphere.

S. F. Vogel and I. C. Barlow of I.B.M. Corporation's Systems Development Division at San Jose, California have developed a solution to the problem by sputtering platinum on to carefully cleaned and etched sapphire and alumina substrates to give strongly adherent films, and they have now described tests carried out to verify their results (*J. Vacuum Sci. Technol.*, 1973, **10**, (5), 843–846). Conventional sputtering of platinum had led to the film blistering and flaking during the heat treatment of the ferroelectric deposit at 950°C, and intermediate films of zirconium or titanium, which normally promote adhesion of noble metals to oxide ceramics or glasses, also failed during heat treatment.

The I.B.M. technique was developed empirically and consists of a two-stage deposition process followed by heat treatment. First oxygen is used as the sputtering gas for 22 minutes, giving a platinum deposition rate of 35 Å per minute. Then argon is used as the sputtering gas for a further 22 minutes, during which the deposition rate increases to 180 Å per minute. It is essential to maintain the sapphire or alumina substrates during sputtering at a temperature of at least 580°C. The heat treatment in air is a controlled temperature rise over six hours to 930°C, maintenance at this temperature for two hours, and slow cooling for 12 hours.

Adhesion tests consisted of scratching specimens with a hand-held tool until failure occurred. Satisfactory adhesion was indicated by the smeared appearance of the platinum in the centre and on the edges of the scratch. Heat treated platinum films adhered much better than as-sputtered films. Crystal structure and topography of single-crystal sapphire, polycrystalline alumina and platinum films were studied by back-reflection Laue photography, diffractometry and scanning electron microscopy. On sapphire the platinum exists either as smooth single crystal material or as material with a dull fibrous texture oriented along the [111] direction. Platinum films on alumina were also fibrous.

While the main purpose of the platinum films was to serve as substrate to ferroelectric films, platinum has also been shown to be the most satisfactory material for contact electrodes deposited on to the exposed surface of the ferroelectric films. It was sputtered in argon to 3000 to 5000 Å on the initial dielectric films, followed by joint firing at 950°C, the temperature of conversion of the dielectric to the ferroelectric films. Alternatively, platinum dots can be deposited on converted films but heating at 600°C in air is then needed to produce satisfactory contact properties.

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