Re-emission coefficients of Si and SiO_2 films deposited through rf and d.c. sputtering. R. E. JONES *et al.*, *J. Appl. Phys.* **38** (12) (1967), p. 4656. Re-emission coefficients for SiO_2 and Si films deposited through rf sputtering have been measured as a function of pressure and input power. Values for SiO_2 were 0·86–0·30 and for Si 0·45–0·07. High re-emission coefficients are correlated with negative potentials on the deposit surface, which, in turn, caused re-sputtering of the deposit by positive ions drawn from the glow discharge. The existence of additional mechanisms for re-emission was established for rf sputtering of Si deposited at zero substrate bias. The re-emission co-efficient of d.c. sputtered silicon was found to have values comparable to those of rf sputtering.

Switching phenomena in titanium oxide thin films. F. ARGALL, *Solid-St. Electron.* **11** (1968), p. 535. Thin films of anodized titanium dioxide can be made to switch between three distinct conductivity states. Some electrical properties which characterize these states are given in the temperature range 4·2°K to 500°K. It is concluded that the reversible switching is not due to a phase change of the dielectric.

TFT instability and stabilization techniques. W. A. GUTIERREZ and H. L. WILSON, *Solid-St. Technol.*, May (1968), p. 33. The cadmium selenide TFT exhibits two basic types of instability: (1) the enhancement mode instability, and (2) the depletion mode instability. The sources of these instabilities and the techniques for reducing them are discussed. By the use of a gate insulator, which includes a reducing layer (e.g. SiO), along with proper heat treatment and encapsulation, the stability of the CdSe TFT can be significantly improved. Its stability is comparable to silicon MOS FETs up to approximately 85°C for gate stress fields of $\pm 3 \times 10^5$ V/cm.

Sputtering—I. Its technology application. T. I. PUTNER and G. N. JACKSON, *Electron. Equip. News*, April (1968), p. 4. This series of three articles is intended as an introduction to the technology and applications of sputtering. Part I deals with the overall process variables and a simple technique for sputtering.

Sputtering—II. Its technology applications. T. I. PUTNER and G. N. JACKSON, *Electron. Equip. News*, May (1968), p. 4. Part II extends to more sophisticated techniques and to reactive sputtering.

Sputtering—III. Its technology applications. *Electron. Equip. News*, June (1968), p. 36. Part III includes a discussion of the various applications of sputtering and the equipment requirements for the various techniques.

The sputtering of nickel-chromium alloys. W. L. PATTERSON and G. A. SHIRN, *J. Vac. Sci. Technol.* **4** (6), Nov./Dec. (1967), p. 343. Ni–Cr alloys having the compositions (in atomic per cent) Ni–22 Cr, Ni–42 Cr, and Ni–80 Cr were sputtered in argon in a low-pressure supported discharge. Ion energy was varied from 200 to 1000 eV, ion current density from 0·1 to 0·8 mA/cm^2 and pressure from 2 to 6 microns. The ion-pumped sputtering tube was processed as a UHV system. Thin films were deposited on polished silicon, aluminium or sapphire. Results showed that the target composition was preserved in the sputtered films to within ± 1 per cent in each component. Near the surface of the sputtered Ni–22 Cr target, a relative Cr enrichment was found. The alloy sputtering process has been codified in a phenomenological continuity equation, using sputtering yields as parameters. The equation gives quantitatively a transient-state and a steady-state solution. The steady-state solution shows that the sputtered film should have the same composition as the target bulk and that the surface of the target should, in general, change composition.

A radio frequency dielectric sputtering system with non-grounded electrodes. L. HOLLAND *et al.*, *J. Sci. Instrum.* (*J. Phys. E.*), *Ser.* 2, **1** (1) (1968), p. 32. An improved r.f. dielectric sputtering system is reported in which sputtering from grounded metal components is avoided by using two insulated lead-ins connecting the r.f. power supply to two metal electrodes backing the dielectric target. One form of the system described consists of a dielectric disc backed by a central disc and an annular electrode. A magnetic field is used to increase the ionization probability and confine the plasma produced by the r.f. electric field; a separate ionizing source is not used. Results are given for the deposition rate of silica sputtered in argon as a function of r.f. power input and for the film thickness distribution over the work area. Using a silica disc of 20·3 cm diameter with a substrate-to-target distance of 3·2 cm, films could be deposited at a rate of 700 Å/min in commercial argon at 4 torr pressure. Film thickness uniformity to better than $\pm$ 5 per cent could be obtained over an area of 200 cm^2.

The epitaxial growth of zinc sulphide on silicon by vacuum evaporation. P. L. Jones *et al.*, *Brit. J. Appl. Phys.*, Ser. 2, 1 (3) (1968), p. 283. Epitaxial layers, up to 5 microns thick, of zinc sulphide have been grown on thermally cleaned (111) surfaces of single-crystal silicon discs. The vacuum system was equipped with aluminium gaskets, which permit the baking of the entire system to 400°C. The silicon furnace, zinc sulphide source, cleaning technique of the silicon surface, and the method of growing the zinc sulphide layers are described. The importance of producing a clean silicon surface and of maintaining constant temperatures during the deposition has been demonstrated.

THICK-FILM CIRCUITS AND MATERIALS

Materials for thick-film technology—state of the art. D. T. DeCoursey, *Solid-St. Technol.*, June (1968), p. 29. Considerable activity is presently under way, utilizing thick-film technology to produce a wide variety of useful, sophisticated hybrid microcircuits. The keys to the advances in this technology are the screen-printable, precious-metal compositions that perform conductor, resistor, capacitor and other functions. This article describes current compositions and several in the development stage, also citing several recent applications of thick-film technology in electronic devices.

Printing of thick-film microcircuits. R. G. Finch, *Microelectron.*, January (1968), p. 14. Thick-film techniques are now available for the production of a wide range of microcircuits. In this article the basic printing techniques are described and, in later articles, baking, firing and bonding techniques will be reviewed. The technology is based on the mechanical printing of suitable inks on to substrates, which are then fired to give conductor, resistor and capacitor patterns. With reasonable control, electrical parameters can be reproduced to within 15 per cent of the mean.

Tooling and part handling systems for thick-film microcircuits. D. C. Hughes, Jr., *Solid-St. Technol.*, June (1968), p. 35. Two basic areas of tooling and part handling are discussed. The first is concerned with part holding tools or fixtures which can be used in a single piece of process equipment such as at the screen print or adjust phases of the production process in flat bed or rotary work table machines. Tooling ranges from fixed pin locating fixtures to elaborate clamping vacuum fixtures. Requirements are compared for substrates of different materials in both plate and disc form. The second area of discussion covers a number of suggested ways to feed and transfer parts between various process operations. Operations from feeding raw substrates on through the print, dry fire, lead-attach, adjust, hybrid component mounting, encapsulation and test are treated.

Thick-film hybrid design—the right way. F. Keister and D. Auda, *Electron. Des. News*, June 10 (1968), p. 56. Advances in thick-film hybrid microcircuit technology made possible by improved screens, masks and inks are gaining more attention from the microelectronics engineer. This collection of "good" and "poor" hybrid circuit design techniques has been gleaned from the practices of several leading manufacturers. It has proved to be a useful engineer's guide for successful designs. Centered around hybrid circuit conductors, resistors, capacitors, discretes and interconnections, these illustrations of good and poor practices underscore correct approaches to be followed by the designer. The ideas presented here will acquaint the circuit designer, beginner and veteran alike, with preferred ways of avoiding pitfalls.

High stability thick-film resistors for commercial applications. G. D. Lane, *Solid-St. Technol.*, June (1968), p. 45. In developing palladium-free, high stability thick-film resistive paste, it has become apparent that by carefully controlling such variables as the temperature of the printing area, paste vehicle, printing methods and firing time and temperature, it is feasible to print resistors with a tolerance of $\pm$10 per cent on a production basis.