LETTERS TO THE EDITOR

DIELECTRIC BREAKDOWN PROPERTIES OF ALUMINIUM NITRIDE FILMS

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Aluminium nitride films find many applications in microelectronic devices due to their chemical inertness, large energy gap and good thermal conductivity. Many authors have studied the preparation and properties of aluminium nitride thin films[1-3]. But very little information is available on the properties of these films prepared by ion plating[4]. The present investigation deals with the study of dielectric breakdown of aluminium nitride films formed by ion plating.

Thin film capacitors of aluminium nitride have been formed on heated glass substrates by reactive RF ion plating technique. The details of the deposition procedure have been given earlier[5]. Aluminium electrodes were used to form MIM sandwich structure using appropriate metallic masks. The areas of the capacitors were in the range 3-5 mm^2. The dielectric film thickness was measured by multiple beam interferometer (Fizeau fringes). The breakdown studies were carried out using a stabilized d.c. power supply. A standard resistor (10 kΩ) was connected between the source and the film. When the breakdown event occurred as shown by an abrupt rise in current, the breakdown voltage across the film was measured using a V.T.V.M.

The d.c. dielectric breakdown measurements have been carried out in the thickness range 300–2000 Å. Figure 1 represents the doubly logarithmic plot of breakdown onset field strength against the thickness of aluminium nitride film capacitors. It has been observed that the breakdown field strength decreases with the increase of film thickness. Also the field strength has been found to be a power-dependent function of thickness (ω) varying as $\omega^{-\alpha}$, where $\alpha = 0.55$. The breakdown field strength has been observed to be in the range 2-8 MV/cm for the various films under investigation. This is in accordance with the studies of Duchene on sputtered aluminium nitride films[3]. Figure 2 shows the variation of the breakdown field strength of aluminium nitride film capacitors with temperature in the range 0° to 80° C. The breakdown field strength is found to decrease with the increase of temperature.

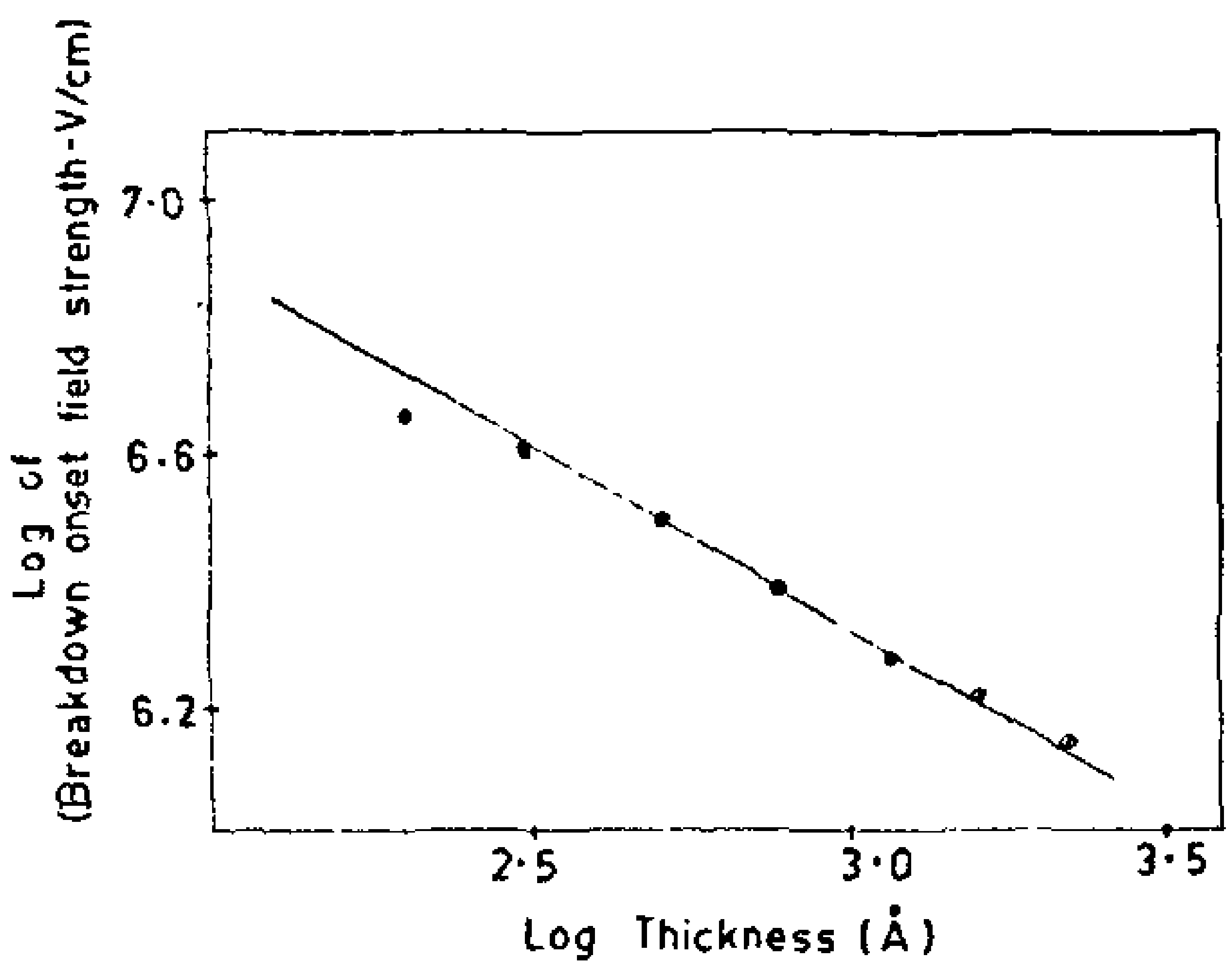


Figure 1. Variation of breakdown onset field strength with film thickness.

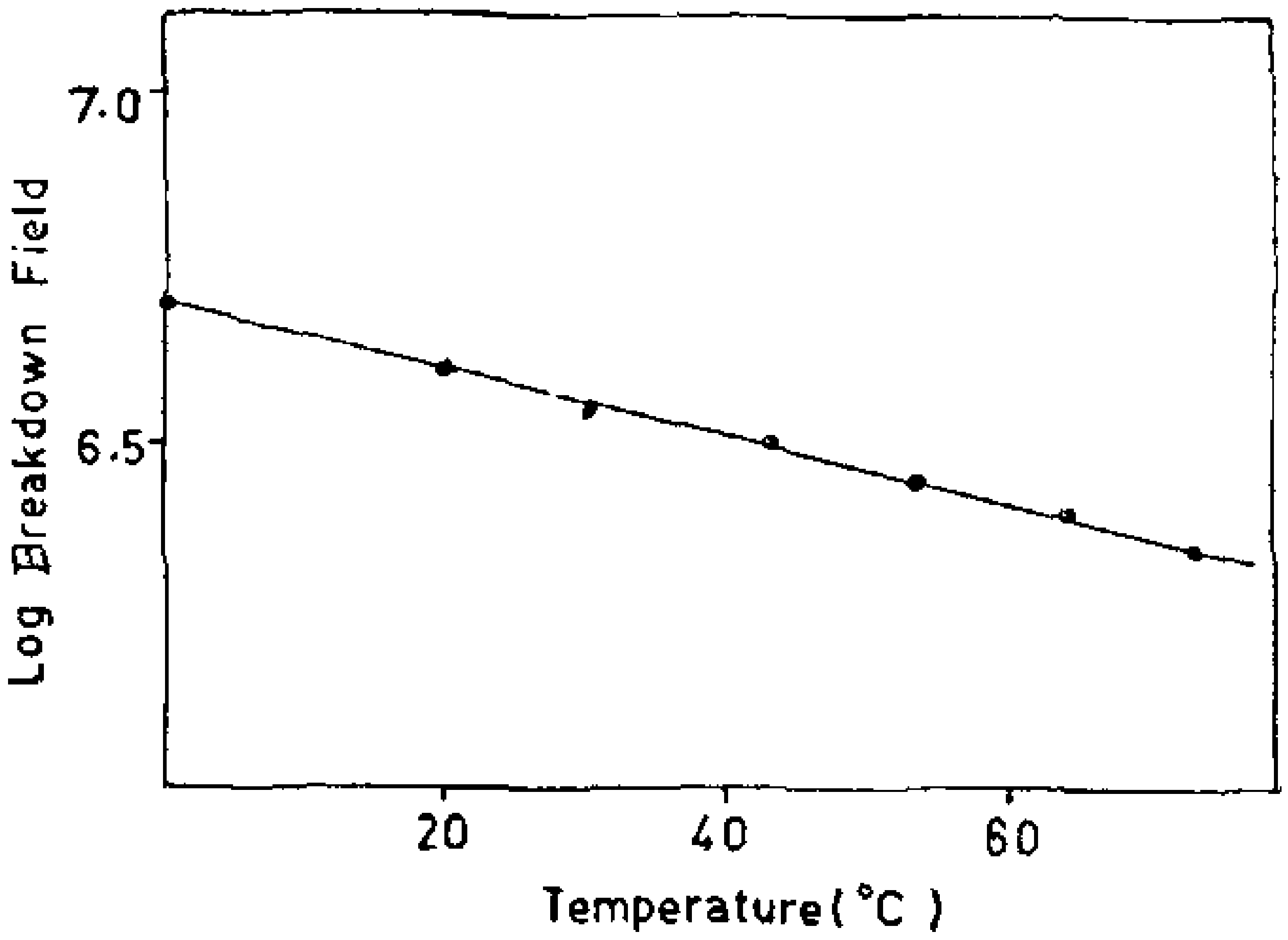
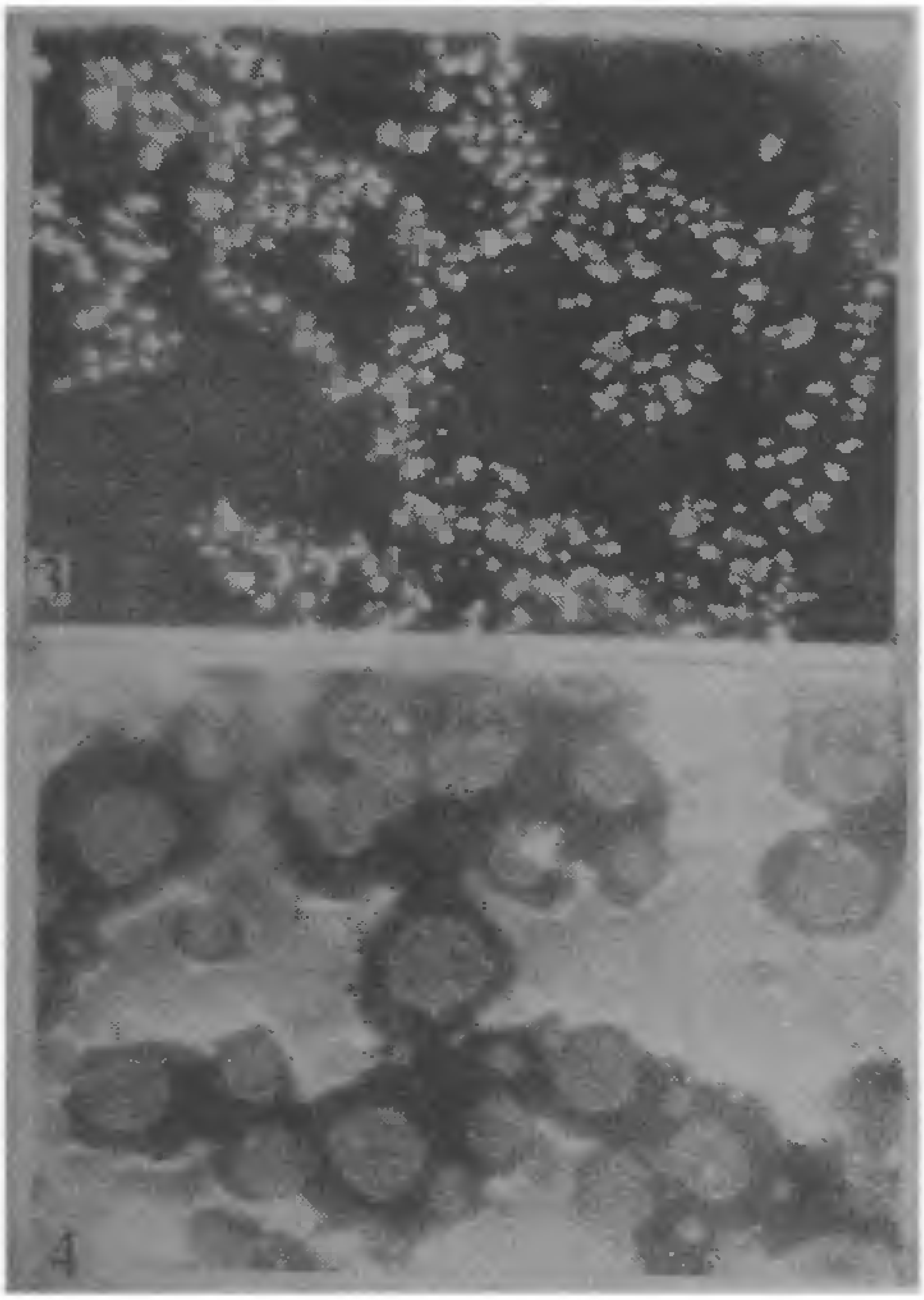


Figure 2. Dependence of breakdown field strength on temperature.

On applying an increasing d.c. voltage to the nitride film capacitors, the onset of breakdown occurred at field strength below 1 MV/cm. With the increasing voltage, the occurrence of breakdown increases rapidly in a fashion which agrees with the observations of others[6,7]. Breakdowns were accompanied by sparks and a typical destruction pattern produced in the present study is shown in figure 3. Figure 4 shows the total destruction caused to the capacitor when the field strength was increased without the series resistor in the circuit.

The dependence of breakdown field strength on the thickness and the temperature of the films and the occurrence of single hole breakdown can be explained on the basis of the electronic avalanche breakdown theory proposed by Forlani and Minnaja[8]. According to Forlani and Minnaja, the breakdown onset field strength (F) varies with the film thickness (ω) as $F \propto \omega^{-\alpha}$ where $\alpha = 0.5$, which is in fair agreement with the present observations. Also they have predicted the relation[9],



Figures 3–4. Micrograph showing single hole breakdowns (× 450). 4. pattern of total destruction.

$$F_b \simeq \frac{Q_{\rm eff}}{kT}\,\frac{\bar{E}}{q}\,\frac{1}{\omega}$$

where $Q_{\rm eff}$ is the effective height of the potential barrier at the cathode-dielectric interface, E the difference between the mean energy of an electron when it is able to ionize and the mean energy of the electrons emerging from an ionization event, q the electronic charge, k the Boltzmann's constant and T the absolute temperature. This equation shows an explicit dependence of the breakdown field strength on temperature. The temperature dependence observed in the present study can be explained satisfactorily on the basis of electron-electron scattering.

The occurrence of single hole breakdown which has been shown in figure 3 can also be accounted for using the electronic avalanche mechanism. One of the limitations of Forlani and Minnaja's theory is that it does not mention other breakdown events, such as the destruction of the films due to thermal instabilities at high fields. In such cases, Klein's theory of localized electronic breakdown[10] gives a more appropriate explanation. The total destruction produced on the films as shown in figure 4, can be explained on the basis of Klein's theory.

1. Noreika, A. J. and Ing, D. W., *J. Appl. Phys.*, 1968, **39**, 5578.
2. Lewis, D. W., *J. Electrochem. Soc.*, 1970, **117**, 978.
3. Duchene, J., *Thin solid films*, 1971, **8**, 69.
4. Murayama, Y., Kashiwagi, K. and Kikuchi, M., *J. Vac. Sci. Technol.*, 1980, **17**, 769.
5. Mangalaraj, D., Radhakrishnan, M., Balasubramanian, C. and Kasilingam, A. R., *J. Phys.*, 1980, **D13**, L101.
6. Klein, N., *Adv. Electron. Electron Phys.*, 1969, **26**, 309.
7. Siddall, G., *Vacuum*, 1959, **9**, 274.
8. Forlani, F. and Minnaja, N., *Phys. Stat. Solidi*, 1966, **4**, 311.
9. Forlani, F. and Minnaja, N., *J. Vac. Sci. Technol.*, 1969, **6**, 518.
10. Klein, N., *Thin Solid Films*, 1971, **7**, 149.

STRUCTURE OF A NEW FLAVONE GLYCOSIDE FROM *IXORA ARBOREA* STEM.

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Ixora arborea (N.O. Rubiaceae) is reputed for its medicinal importance[1,2]. Literature survey revealed that no work has been done on the stem of this species, and only little work is reported on other species[3].

The yellow coloured glycoside, $C_{21}H_{20}O_{11}$, m.p. 148–50° was isolated from the ethyl acetate extract of the water soluble fraction of ethanolic concentrate of the stem. It was found to be a single entity by PC and TLC.

Acid hydrolysis (7% ethanolic H_2SO_4) of the glycoside afforded an aglycone and a sugar which was identified as D-galactose by PC and osazone formation and confirmed by direct comparison with the authentic sample of D-galactose.

The aglycone, $C_{15}H_{10}O_5$, m.p: 338–40° was assigned a flavone structure on the basis of UV data, colour reactions and degradation studies. It was found to contain three-OH groups as it formed a triacetate (m.p. 175–78°) (IR peak at 3350 cm^{-1}) and no methoxyl group (negative results in Zeisel's estimation). Positions of different groups were established by different colour rection and UV shifts with different reagents[4]. A bathochromic shift of 38 nm with 1% methanolic $AlCl_3$ and a bathochromic shift of 7 nm with fused sodium acetate indicated the presence of —OH at positions-5 and -7 respectively. The remaining third —OH group was located on the basis of results of potassium permanganate oxidation. The aglycone