was established quite early in the earth history. Apparently the sialic crust that preceded the formation of the Dharwar greenstone belts was thicker and stronger, capable of supporting stable zone volcanism, sedimentation and biological activity. By contrast the greenstone belts of Karelia in the Baltic shield might have evolved on thin, less stable sialic crust. Association of immature sediments with bimodal,/polymodal volcanics in the Baltic shield indicates an island arc setting. By contrast, bimodal volcanic rocks associated with both mature and immature sediments in the Dharwar belts point to a back-arc environment.

That the Archaean greenstone belts evolved in a variety of tectonic environments and that no single model is universally applicable is demonstrated by the fact that (i) even in a single region such as the Baltic shield, greenstone belts comprise either bimodal and polymodal volcanic suites, and (ii) the volcanosedimentary and metallogenetic assemblages of the Dharwar and the Baltic shields show significant difference in characters.

1. Windley, B. F., *Tectonophysics*, 1984, 105, 43.
2. Eriksson, K., 3rd International Archaean Symposium, Abstracts Volume, 1990, pp. 279–282.
3. Kroner, A., Pustinen, K. and Hickman, M., *Contrib. Mineral. Petrol.*, 1981, 76, 33.
4. Bibikova, V. S., et al., *DAN USSR*, 277, 1984, N2, 442–444 (Russian).
5. Lobach-Zhuchenko, S. B., Levchenkov, D. A., Chekulaev, V. P. and Krylov, I. N., *Precambr. Res.*, 1986, 33, 45.
6. Beckinsle, R. D., Drury, S. A. and Holt, R. W., *Nature*, 1980, 283, 469.
7. Taylor, P. N., et al., *J. Geol. Soc. India*, 1988, 31, 155.
8. Bhaskar Rao, Y. J., Naha, K., Srinivasan, R. and Gopalan, K., *Proc. Indian Acad. Sci. (Earth and Planet. Sci.)*, 1991, 100, 399.
9. Gorbatschev, R. and Gaal, G., *History of the Baltic Shield*, American Geophysical Union, 1987, pp. 149–159.
10. Gaal, G., *Bull. Geol. Soc. Finland*, 1986, 58, 149.
11. Drury, S. A., *Geochim. Cosmochim. Acta*, 1983, 47, 317.
12. Hussain, S. M. and Naqvi, S. M., *Geol. Soc. India, Mem. 4*, 1983, 73.
13. Jaffri, S. H., Khan, N., Ahmed, S. M. and Saxena, R., *Geol. Soc. India, Mem. 4*, 1983, 110.
14. Srikantiah, S. V. and Bose, S. S., *J. Geol. Soc. India*, 1985, 26, 407.
15. Charan, S. N., Naqvi, S. M. and Ramesh, S. L., *J. Geol. Soc. India*, 1987, 32, 343.
16. Srinivasan, R. and Sreenivas, B. L., *J. Geol. Soc. India*, 1972, 13, 47.
17. Swami Nath, J. and Ramakrishnan, M. (eds.), 'Early Precambrian Supracrustals of Southern Karnataka', *Geol. Surv. India Mem. 112*, 1981, pp. 1–350.
18. Srinivasan, R. and Ojakangas, R. W., *J. Geol.*, 1986, 94, 199.
19. Srinivasan, R. and Naqvi, S. M., in *Precambrian Continental Crust and its Economic Resources*, (ed. Naqvi, S. M.), Elsevier, 1990, pp. 245–266.
20. Pichamuthu, C. S. and Srinivasan, R., *Geol. Soc. India, Mem. 4*, 1983, 121.
21. Naha, K., Srinivasan, R. and Naqvi, S. M., *Q. J. Geol. Min. Met. Soc. India*, 1986, 58, 219.
22. Raase, P., Raith, M., Ackermand, D. and Lal, R. K., *J. Geol.*, 1986, 94, 261.
23. Srinivasan, R., *Indian J. Geol.*, 1988, 60, 57.
24. Radhakrishna, B P., *Geol. Soc. India, Mem. 4*, 1983, 1.
25. Mekarikhin, V. V. and Kononova, G. M., *Lower Proterozoic Phytolites of Karelia*, Academy of Sciences, USSR, Nauka, Leningrad, 1983, 1–180 (in Russian).

Microstructure of HPZ-Si$_3$N$_4$ fibre

V. S. R. Murthy* and M. H. Lewis
Centre for Advanced Materials Technology, University of Warwick, Coventry CV4 7AL, UK
*Present address: Department of Metallurgy, Indian Institute of Technology, Kanpur 208 016, India

Microstructure and reactivity (with a silicate matrix) of a new silicon nitride fibre were examined. The fibre was non-crystalline in as-received state and contained oxygen and carbon as impurities. ^{29}Si magic angle spinning nuclear magnetic resonance (MAS-NMR) study indicated the presence of SiN$_4$, SiC$_4$ and their mixed coordinations in the structure. Further, when these fibres are incorporated in a magnesium aluminosilicate matrix, a silica-rich reaction layer with small amount carbon precipitation has been observed at the fibre-matrix interface.

DURING the past decade there has been a marked increase in the availability of high-strength, high-modulous ceramic fibres for use in polymer, metal and ceramic matrix composites. Fibres based on the compounds of SiC and Si$_3$N$_4$ have greater potential than carbon due either to reduced reactivity during processing or improved stability in oxidizing conditions. Among various non-oxide fibres, the most developed system is silicon carbide, although there is interest in silicon nitride and in other nitrides and carbides.

There are two main routes for the production of non-oxide fibres, viz. (i) chemical vapour deposition (CVD)[1,2] and (ii) pyrolysis of organopolymeric precursors[3,4]. Fibres produced via organic precursor route are fine in diameter (8–15 μm), flexible and cheaper than those produced by CVD technique. Fibres obtained by this method not only enjoy advantages such as high purity, low-temperature processing, varying composition, etc., but also convenient from the viewpoint of fabrication. Additionally, SiC fibres synthesized from organic precursors have a silicon–oxy-carbide constitution, with excess carbon dispersed as micro-crystalline graphite[5]. During high-temperature densification of composites (which is usually below glass liquidus), a controlled reaction between silicate and silicon-oxy-carbide produces a carbon-rich reaction layer (of the order of 20–250 nm) at the interface and the effect of such low-cohesive interfaces on mechanical behaviour of ceramic matrix composites is well known[6-8].

Like silicon carbide fibres, in the recent past, there have been attempts to produce high-strength, refractory silicon nitride fibres from organic precursors. In one method, fibres are produced from polycarbosilane and are electron-cured or oxidation-cured in NH_3 atmosphere[9]; whereas in the other, fibres are derived from hydridopolysilazane (HPZ, Dow Corning Corporation, USA; a reaction product of trichlorosilane and hexamethyldisilazane) and are ultimately cured in nitrogen[10]. HPZ fibre (Si:C:N:O = 57:28:10:4) possesses tensile strength of the order of 2.50 GPa and claimed to be stable up to 1400°C. Here we present results obtained on structure and reactivity (with a silicate matrix viz. magnesium aluminosilicate) of HPZ fibre.

As-received HPZ fibres are elliptical in shape and the diameter varies from 10 to 15 μm. Transmission electron micrograph exhibits a phase contrast fine structure (Figure 1), which may originate from excess carbon precipitated in graphite form. Apart from silicon, nitrogen and carbon, the fibre also contains small proportion of oxygen. Further ^{29}Si MAS-NMR spectrum obtained on these fibres shows a peak at -47 ppm. The broad NMR spectral peak is based on SiN_4 coordination with an asymmetric peak broadening towards the SiC_4 polytypic structures indicative of mixed (C,N) coordination (Figure 1).

To examine the reactivity between silicon nitride fibre and a silicate matrix, chopped fibres are incorporated into a aluminosilicate matrix and hot pressed at 950°C for 1 h. Interfaces in these composites show a cellular structure believed to be phase-separated mixture of silica with residual carbon (Figure 2). The evolved nitrogen would have partially dissolved in the matrix glass prior to crystallization or, in some instances, evolution of gas bubbles was also observed. The silica-rich interfaces have not been mechanically characterized, but are unlikely to provide the low stresses associated
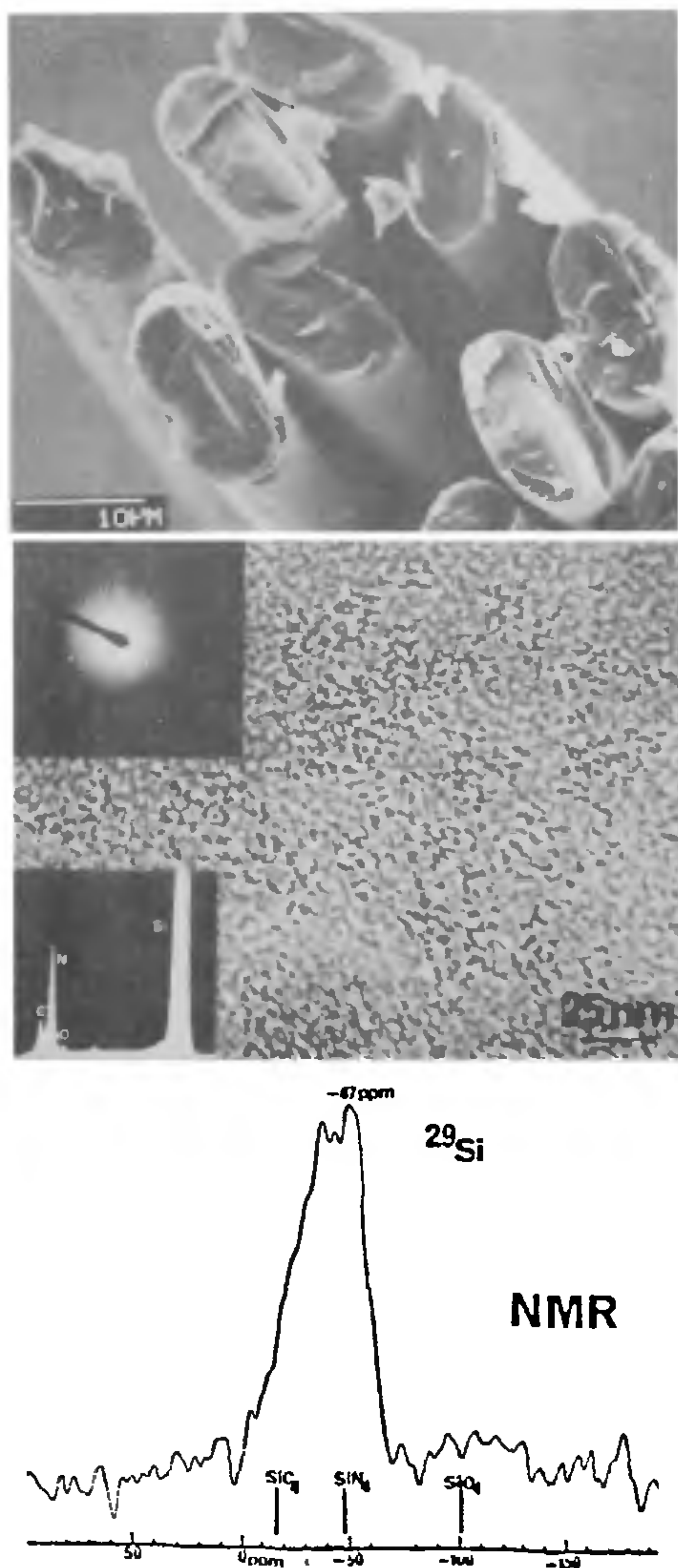

Figure 1. Scanning and transmission electron micrographs and ^{29}Si NMR spectrum from a Si N C O fibre.

with high carbon enrichment, e.g. interfaces in SiC fibre reinforced silicate matrix composites. Further, these interfaces are also susceptible to rapid oxidation and silica bridging at elevated temperatures.
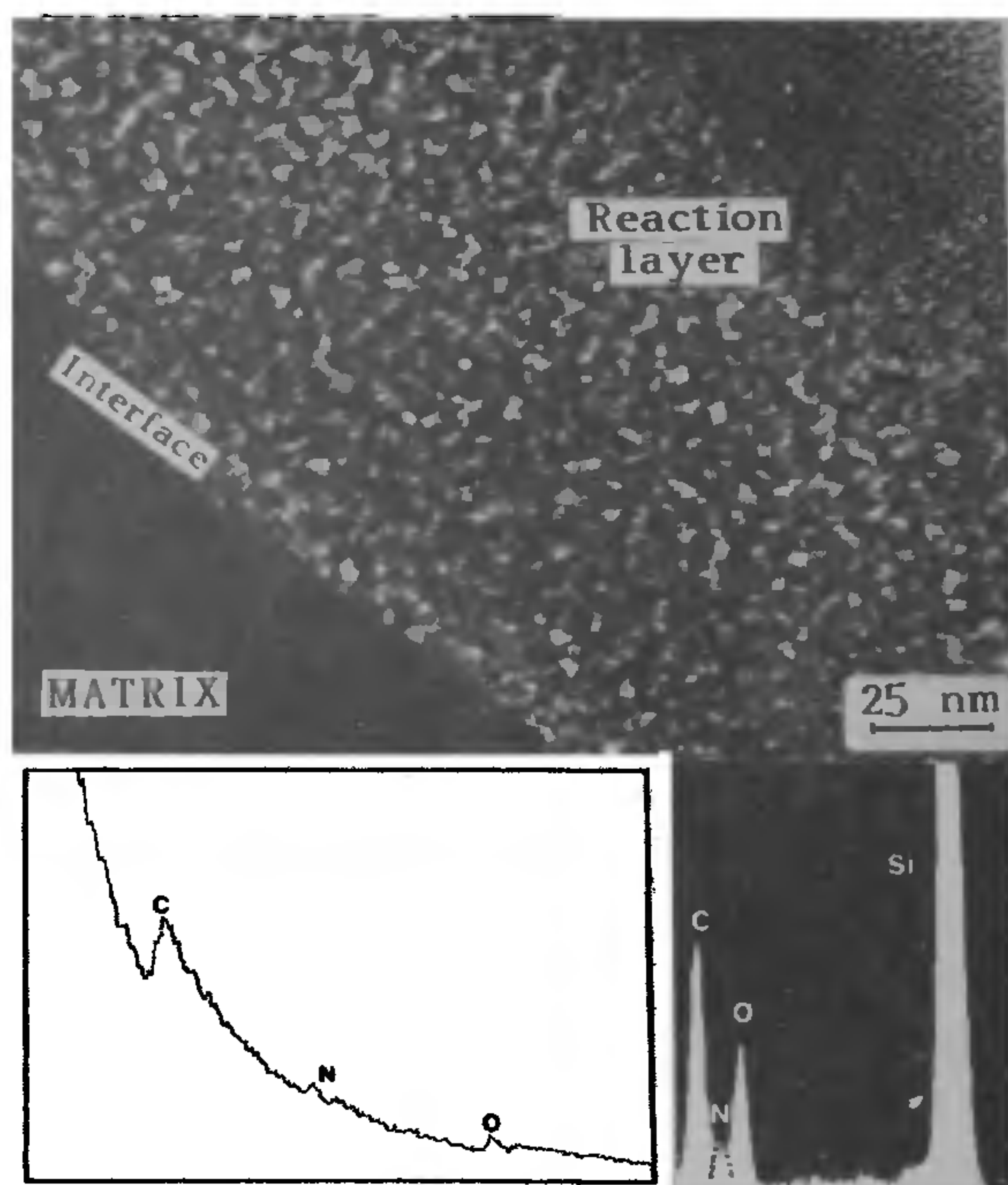
Figure 2. Interface reaction layer in a MAS/HPZ nitride-based fibre composite with accompanying EELS and EDAX analysis.

1. Dicarlo, J. A., *J. Met.*, 1985, 37, 44.
2. Wawner, F. W., Teng, A. Y. and Nutt, S. R., *SAMPE Q.*, 1983, 14, 39.
3. Yajima, S., Okamura, K., Hayashi, J. and Omori, M., *J. Am. Ceram. Soc.*, 1976, 59, 324.
4. Yamamura, T., Ishikawa, T., Shibuya,M. and Okamura, K., *J. Mat. Sci.*, 1988, 23, 2589.
5. Yajima, S., Okamura, K., Matsuzawa, T., Hasegawa, Y. and Shishido, T., *Nature*, 1979, 279, 706.
6. Brennan, J. J., *Ceramic Microstructures: The Role of Interfaces* (eds. Pask, J. A. and Evans, A. G.), Plenum, New York, 1988, p. 387.
7. Chaim, R. and Heuer, A. H., *Adv. Ceram. Mater.*, 1987, 2, 154.
8. Murthy, V. S R., Pharaoh, M. W. and Lewis, M. H., *New Materials and their Applications*, Institute of Physics, U K, 1990, (in press).
9. Okamura, K, Sato, M., Matsuzawa, T., Seguchi, T. and Kawanishi, S., *Ceram. Engg. Sci. Proc.*, 1988, 9, 909.
10. Legrow, G. E., Lim, T. F., Lipowitz, J. and Reaoch, R. S., *Am. Ceram. Soc. Bull*, 1987, 66, 363.

Structure of sola wood: the traditional Indian art material

M. N. B. Nair and H. Y. Mohan Ram

Department of Botany, University of Delhi, Delhi 110 007, India

Sola wood, produced by the Indian aquatic shrubs *Aeschynomene aspera* and *A. indica*, is the lightest wood known. It is a marble-white, soft, and spongy material used by traditional Indian craftsmen to produce a wide range of decorative articles. In commerce this wood is erroneously called sola pith. Sola results from the activity of vascular cambium and has all the components of wood (secondary xylem). The present work provides the structural basis of the varied uses of this versatile natural material. Wood structure is similar in both the species except for the presence of growth rings in *A. aspera*. The wood is storied and diffuse porous. The frequency of vessels is extremely low. Inter-vessel pits are bordered and vestured. A few vessels have vestures or helical thickenings on the inner surface of their walls. Axial parenchyma is paratracheal vasicentric or scanty vasi-