the platinum wire. Triangulation (a method that allows finding a position by combining three others) between the positions of the incident beam, the platinum wire and the shading of the diffracted image allows the identification of the portion of specimen that produces the diffraction signal. In addition, the diffraction spots provide the local lattice spacing and lattice-spacing distribution. The spatial resolution is still far from what TEM provides routinely, but it is close to what can be achieved today[1–5,6].

The fundamentals of plastic deformation of crystals containing a dislocation cell structure were developed more than twenty years ago and are described in the so-called composite model[7]. The basic idea is that the cell-wall regions of high dislocation density are harder than the cell-interior regions of low dislocation density. Under the action of an externally applied stress, both cell walls and cell interiors are assumed to deform compatibly. The deformation induces internal stresses of the same sign as the external stress in the cell walls, and of opposite sign (or 'back') in the cell interiors. The X-rays probe the lattice strains due to dislocations and, at the same time, the superimposed external and internal stresses. The results of early TEM observations and X-ray diffraction experiments on deformed single crystals of copper were consistent with the composite model[7,8], and revealed the presence of long-range internal stresses within the cell structure of the crystals, as shown schematically in Fig. 1. In particular, it could be shown that the X-ray-diffraction line profiles exhibited a characteristic asymmetric line broadening. It can be shown that this is a direct consequence of the presence of long-range internal stresses[7,8]. Nevertheless, some questions remained open, partly related to the fact that the results obtained in these earlier X-ray studies were not spatially resolved but represented average values from larger regions.

The merit of the work by Levine and co-workers[5] lies in the fact that, in their X-ray-diffraction experiments, the diffracted signals are highly spatially resolved and in a one-to-one correlation with well-defined regions of submicrometre size in the cell interiors of the crystal. Thus, the authors could conclude from the shifts of the X-ray-diffraction profiles obtained from small local regions, that long-range internal back-stresses prevailed in the cell interiors of their specimens that had been deformed in tension or in compression. Moreover, the internal stresses could be assigned unambiguously to one particular cell-interior region from which the diffracted intensity came. Another interesting new feature of these findings is that the magnitude of the internal back-stresses varied markedly from one cell interior to the next, indicating a significant fluctuation. This observation provides further direct evidence that fluctuations are an inherent feature in deformed microstructures, in line with earlier work of others[9–11]. Finally, Levine and co-workers could also show that the average diffraction profiles, obtained from larger volumes of the same crystal, exhibit characteristic asymmetrically broadened line profiles, similar to the earlier observations[7,8]. All these facts confirm that the principles of the composite model are correct.

The recent studies by several groups that made use of the different high-performance synchrotron facilities[1–5] have demonstrated the potential of these techniques as powerful tools in the advanced microstructural analysis of deformed crystalline materials. In principle, it is now possible to analyse dislocation structures, also in deeply embedded regions[3,4], with respect to dislocation densities, internal stresses and lattice misorientations on a submicrometre scale[1–5]. Furthermore, first attempts to follow *in situ* the characteristics of the dislocation distributions evolving during plastic deformation have been encouraging[4]. Altogether, these developments open new perspectives for future studies of remaining problems related to the composite model of heterogeneous dislocation structures and to the dual role played by unpaired excess dislocations of the same sign, namely the so-called geometrically necessary dislocations, in the evolution of both long-range internal stresses and lattice misorientations[12]. Another rewarding task would be to apply the new diffraction techniques to study the differences in the deformation mechanisms and dislocation microstructures prevailing in the near-surface regions and in the bulk of deformed crystals, respectively.

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ANODES SLICED WITH IONS

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