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京都大学グローバルCOE「統合物質科学」セミナー

【日時】　2010年　3月　17日(水)　14:00～16:00

【場所】　吉田キャンパス　物理系校舎3階314講義室

Non-planar dislocation cores: A ubiquitous phenomenon

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Dislocation characteristics and behaviour in close-packed crystals, in particular FCC, have been habitually regarded as the standard for description of dislocation properties in all crystalline materials. However, as stated by Sir Alan Cottrell in his closing address at the meeting to celebrate the 50th Anniversary of the Concept of Dislocations in Crystals: “For too long we have taken the FCC dislocation as the paradigm of all dislocation behaviour; but, as the studies of BCC screw dislocations have shown, the FCC structures and properties are the exception rather than the norm.”An inherent assumption is that dislocations are fully confined to their slip planes. However, we will show that this dislocation behaviour is very special and that it is considerably more common that for some orientations of the dislocation line the cores extend into several non-parallel crystal planes. These orientations of the dislocation line the cores extend into several non-parallel crystal planes. These dislocations then control plastic properties and non-planar cores lead to phenomena not expected within the simple prototype of dislocation behaviour. In this talk we will present and discuss a number of such cases. The most widely recognised example is the screw dislocation in BCC metals and we will show results of extensive computer modelling of this dislocation in transition metals that reveal a complex dependence of the Peierls stress on the applied stress tensor, leading to the significant influence of shear stresses perpendicular to the glide direction upon the plastic flow. Similarly, studies of the atomic structure of dislocations in hexagonal metals, in particular **c+a** dislocations on pyramidal planes, reveal many non-planar core configurations that may explain the very high CRSS for pyramidal slip. Non-planar cores have also been found in many intermetallic compounds. In the case of Ni_3Al formation of non-planar sessile cores by a mechanism akin to the cross slip, explains the anomalous increase of the yield stress with increasing temperature. Another interesting case is the inverse brittle-to-ductile transition at high temperatures occurring in $SrTiO_3$, which is, presumably, the consequence of the formation of non-planar cores of edge dislocations via climb. However, non-planar dislocation cores are by no means limited to metallic materials but play an important role in covalently bonded crystals, including molecular crystals, and several examples will be presented.

GCOEプログラムの一環として招聘致しました。多数の院生、学生、教職員の皆さまのご来聴を歓迎致します。

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