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研究论文

几种单晶半导体材料在压痕下的变形与断裂行为比较

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摘要:

采用显微压痕方法研究了Si、Ge、GaAs和InP四种半导体单晶的变形与断裂行为.通过测量[100]取向单晶体面内的显微硬度、裂纹开裂的临界压痕尺寸以及断裂韧性, 分析了这四种材料力学性能的面内各向异性行为. 结果表明: 在压痕载荷的作用下, Si和Ge的塑性变形以剪切断层为主, 而GaAs和InP则通过滑移系的开动协调变形. [100]取向的Si、Ge、GaAs和InP四种单晶的面内显微硬度、弹性模量和断裂韧性表现出不同程度的各向异性. 裂纹长度与压痕尺寸间的关系表明, 与GaAs和InP相比, Si、Ge具有较小的临界压痕尺寸和拟合直线斜率, 这一临界压痕尺寸和拟合直线斜率的变化规律分别与材料的硬度和断裂韧性的变化规律一致.

关键词: 无机非金属材料 半导体材料 显微硬度 变形 断裂 各向异性

Comparison of indentation-induced deformation and fracture of several kinds of semiconductor single crystals

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Abstract:

Micro-indentation method was used to study deformation and fracture behavior of Si, Ge, GaAs, InP single crystals. In-plane microhardness, critical indentation size and fracture toughness of the [100] oriented crystals were measured to analyze anisotropic mechanical properties of these materials. The results show that under the indentation load, Si and Ge deformed through the formation of shear faults, while the activation of slip systems accommodated the deformation of GaAs and InP. The microhardness, elastic modulus and fracture toughness exhibit anisotropic at different extent. The relationship between crack length and indent size shows that the critical indent size and the linearly-fitted slope of the crack length vs. indent size of Si and Ge single crystals are smaller than that of GaAs and InP. The variations of the critical indent size and the linear slope are consistent with that of the hardness and fracture toughness.

Keywords: inorganic non-metallic materials semiconductor microhardness deformation fracture toughness anisotropy

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