Effect of low-energy ion irradiation on T_c of MgB_2

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The superconducting state is characterized by the superconducting order parameter with the amplitude and phase. According to the BCS–Eliashberg theory, the superconducting critical temperature (T_c) suppressed by disorder is owing to a change in the amplitude of the superconducting order parameter associated with the superconducting energy gap. However, several experimental results showed that strongly disordered superconductors had spatial fluctuations in the superconducting order parameter, such as in the form of the superconducting islands. In this case, global phase coherence between superconducting islands has an important role in the superconducting state. To study the effect of disorder on superconductors, we investigate the effect of low-energy ion irradiation on the T_c of MgB_2 thin films. The disorder level generated by ion irradiation is expressed as the value of average displacements per atom (dpa_{avg}). An increase in dpa_{avg} systematically suppresses the T_c. The debye temperature affecting T_c is not significantly changed by dpa_{avg}. Using the McMillan equation, we estimate the dpa_{avg} dependence of the electron-phonon coupling constants (λ) and find that λ is linearly proportional to dpa_{avg} for $dpa_{avg} \leq 0.049$. However, for $dpa_{avg} >$ 0.049, the λ deviates from the linear relationship and decreases more slowly. In addition, the magnetic field-induced superconductor-insulator transition (SIT) occurs at low temperatures. According to the dirty bosonic model, SIT is caused by the loss of phase coherence between superconducting islands. Therefore, we will discuss SIT of disordered MgB_2 and the effect of global phase coherence on the T_c of MgB_2.