Sapphire nanostructure fabrication method based on hydroxyl dehydration condensation

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Sapphire is widely used in the field of epitaxial growth due to its stable chemical properties at high temperature, mature production process and low cost. As the most important substrate material for light-emitting diodes, sapphire occupies more than 90 % of the market. Due to the lattice mismatch and thermal expansion coefficient mismatch between sapphire substrate and epitaxial layer, there is always dislocation density in the epitaxial layer, which can be reduced by manufacturing pattern on sapphire substrates. However, the existing pattern manufacturing methods have the disadvantages of high cost and complicated process. In this study, a method based on hydroxyl dehydration condensation to manufacture nanostructure is proposed. The friction between SiO_2 and sapphire induces hydroxyl dehydration condensation, and the reaction equation is : Al-OH + Si-OH $\rightarrow$ Si-O-Al + H_2O. Since the Si-O-Al bond has a greater bonding strength at the SiO_2 end, the Si-O-Al bond will break at the sapphire end and transfer to SiO_2 during the process of friction. At the same time, the sapphire atoms around the Si-O-Al bond will be affected and move in a direction, thereby generating a layered stepped structure. Based on the above principle, successfully fabricated nanostructure with a height of about 4 nm and a period of about 100 nm on the surface of sapphire, and verified the material transfer process by XPS. AlN of 40 nm was epitaxially grown on sapphire substrate with nanostructure substrate and nonstructure substrate by atomic layer deposition. The surface roughness and crystal quality of the epitaxial layer were characterized by AFM and XRD. The results show that the surface roughness of the epitaxial layer on a nanostructure substrate decreases by 50 % compared with that grown on an unstructured substrate, and the crystal quality is increased by 3 times.