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Catalytic free technique for Synthesis of InN nanostructures

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I. INTRODUCTION

It is technologically important to fabricate defect free InN nanostructure using vapor transport method without any metal catalyst. There are several reports on the synthesis of InN nanowires (NWs) [1], nano-dots [2] etc using vapour-liquid-solid deposition (VLS) technique by Au catalyst. In this report, we have described about a one-step oblique angle deposition (OAD) (catalytic free) technique for the fabrication of different shaped InN nanostructures. The physical shape of the InN nanostructures were simply modified by varying the conditions of growth. The growth was carried out using a customize system by PRO-VAK, Pune, India. High purity indium oxide (In_2O_3) powder (99.99%, Sigma Aldrich, USA) and Indium (In) powder (99.99%, Sigma Aldrich, USA) mixture used in 1:2 weight ratio as starting material, were placed in a quartz boat. The quartz boat was loaded at one end of a 4 inch diameter furnace at hot zone. On the other end, RCA cleaned p-type Si ⟨100⟩ substrate (1-30 Ω cm; Ted Pella, USA) was fixed at 85^0 angle (α) with the axis of the horizontal tube in cold zone. The source and substrate distance was kept at 60 cm. The quartz tube was first evacuated and then high purity nitrogen gas (200 SCCM (standard cubic centimetre per minute)) flushed for 30 minutes.

The first deposition was carried out for 80 minutes. The source temperature was kept at $920\text{-}930^0$ C and growth temperature at $525\text{-}530^0$ C. The field emission scanning electron microscopy (FESEM) image (fig. 1 (a)) shows that the formation of clusters. The second deposition was carried out for 30 minutes. The FESEM (45^o tilted) image shows the formation of nanopine structure (fig. 1 (b)), which consists of nanoparticles of diameter 50 nm. In third deposition, the source temperature was decreased to 850^0 -860^0 and substrate temperature kept at 525^0 $^-530^0$ C. The deposition was carried out for 30 minutes. The FESEM (45^0 tilted) (fig. 1 (a)) shows the formation of nanowire structure of average diameter ~ 50 nm and ~ 1 μm long. In the above three cases, the high-purity ammonia gas was flowed at 200 SCCM. The detail characterization of the nanopine structure and its infrared detection has recently been discussed by the authors [3].

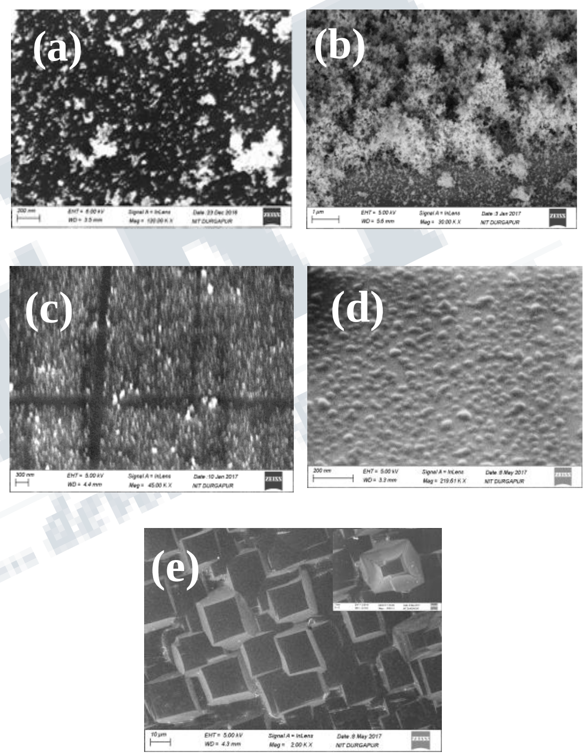

Fig.1. FESEM images in different growth condition under OAD

In case of forth deposition, we have changed both temperature of the source, the substrate and the flow rate of the reaction gas. The source temperature was decreased to $840\text{-}850^o$C and substrate temperatre increased to $640\text{-}650^o$C under NH_3 and N_2 flow rate of 120 SCCM. The FESEM (45^0 tilted) image shows the formation of quantum dot structure (fig. 1(d)) of average diameter ~30 nm. Again, the source temperature decreased to $740\text{-}750^o$C by keeping the other conditions constant including rate of flow of reaction gasses. The shape of the nanostructure suddenly chaged to pyramidal shape having top diameter of 20 μm.

Therefore, we have found out the conditions of synthesis of different shape nanostructure using a catalytic free vapour transport method under OAD. All the nanostructures have their own advantages in optoelectronic device applications. We are interested to understand their application in the field of nanophotonics.

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