H2 dilution effect in the Cat-CVD processes of the SiH4/NH; system

Abstract

Gas-phase diagnostics in the catalytic chemical vapor deposition processes of the $SiH_4/NH_3/H_2$ system were carried out to examine the effect H_2 dilution. The decomposition efficiency of NH_3 showed a sharp decrease with the introduction of a small amount of SiH_4, but this decrease was recovered by the addition H_2 when the NH, pressure was low. On the other hand, at higher NH, pressures, the decomposition efficiency showed a minor dependence on the H; partial pressure. The addition ofSiH4 to the NH; s/stem decreases the H-atom density by me order of magnitude, but this decrease is also recovered by H_2 addition. H atoms produced from H_2 must re-activate the catalyzer surfaces poisoned by SiH_4 when the NH_3 pressure is low.

I. Introduction

Catalytic chemical vapor deposition [Cat-CVD], Often called hot-wire CVD, is one of the most promising techniques for preparing thin amorphous silicon nitride (SiNx) films at low substrate temperatures using SiH_4 and NH_3 as material gases. SiNx films thus prepared can be used as gas- and water-resistant coatings for organic and inorganic devices and as interlayer insulating films for microelectronic devices. One of the problems in this technique has been the low decomposition efficiency of NH_3 in the presence of SiH_4.

ln the absence of SiH_4, NH_3 can be decomposed to NH; and H with a decomposition efficiency of more than 50% . However. the decomposition efficiency decreases sharply upon the introduction of a small amount of SiH_4 . This decrease has been attributed to the poisoning of the catatlyzer surfaces by SiH_4 Separating the catalyzers, one to decompose NH, and another to decompose SiH_4 is not easy because the diffusional rate of Sill, is large under low pressure conditions. such as those employed in conventional low-pressure CVD processes, and the prevention of catalyzer poisoning is difficult.

Recently, it has been found that the addition of H_2 improves not only the

decomposition efficiency of NH; in the presence of Sill. but also the SiNx film quality.For example, Malian et al. have shown that the content of N atoms in the films increases significantly with H_2 dilution for a given NH_3/SiH_4 gas flow ratio. H_2 dilution also causes a reduction in the amount of N-H bonding in SiN_X films. Wang et al. have demonstrated that near perfect conformal surface coverage can be obtained on a 100-nm-scale object [6]. ln the present work. a systematic study was carried out to determine the catalytic decomposition efiiciency of NH_3 in the $SiH_4/NH_3/H_2$ system. Such information is essential for optimizing of the deposition conditions to prepare SiNx contiarmal films. The absolute H-atom densities were also measured under several conditions.