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Solar Energy Materials & Solar Cells 90 (2006) 2338–2345
Solar Energy Materials & Solar Cells
www.elsevier.com/locate/solmat

Thin films of GeC deposited using a unique hollow cathode sputtering technique

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Available online 19 April 2006

Abstract

Experimental results on thin films of the new material Ge_xC_{1-x}, deposited by a unique dual plasma hollow cathode sputtering technique are presented here. The (Ge, C) system is extremely promising since the addition of C to Ge has reduced the lattice dimensions enough to allow a lattice match to silicon, while increasing the bandgap close to that of c-Si. The most important contribution of this work shows that by the non-equilibrium growth conditions present using the hollow cathode technique, one can grow Group IV materials which cannot otherwise be grown using normal CVD or MBE processes. The sputtering is accomplished by igniting a DC plasma of the Ar and H_2 gases which are fed through Ge and C nozzles, cylindrical tubes 30 mm in length with an 8 mm OD and a 3 mm ID.

Keywords: Germanium carbide; Hollow cathode; Optical absorption

1. Introduction

The purpose of this research is to experimentally explore thin films of the new material Ge_xC_{1-x} deposited by a unique dual plasma hollow cathode sputtering technique. Using the hollow cathode technique, one can grow Group IV materials which cannot otherwise be grown using normal CVD or MBE processes. Recently, a significant advancement in the

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doi:10.1016/j.solmat.2006.03.007

deposition of this material has been achieved by electron cyclotron resonance (ECR) plasma deposition [1,2]. This work has yielded films with band gaps of 1.1 eV and with significantly greater optical absorption than c-Si. Unfortunately, only about 3% C can be incorporated into these films. Other groups [3] have grown films with much higher concentrations of C, up to 9%, using traditional magnetron sputtering of two targets, but difficulty was encountered in growing crystalline films at thicknesses greater than 50 nm.The results presented here indicate that these films are comparable with those using planar magnetron sputtering, but with crystalline films much thicker than 50 nm.

2. Experimental details

The experimental setup is described in several prior publications [4–7] and the hollow cathode is described schematically in Fig. 1. The differences between this setup and the prior setup are minimal, here the carbon target replaced the Si target. In this system Ar and H_2 gas are flowed through the Ge and C nozzles and an intense plasma is excited within the nozzle, sputtering the nozzle material at a high rate. The gas reaches a supersonic speed and forces all the material in the direction of the substrate.

Deposition conditions were varied for several samples. The substrate temperature during deposition was 350 °C for all films. The parameters that had the greatest effect on film deposition rate and, consequently on carbon concentration were the power delivered to the Ge and to the C nozzles. Surprisingly, the flow rate of Ar and H_2 had little effect except in the C nozzle where, to ensure plasma stability, the H_2 flow was removed early in the experiments. Substrate distance also had an effect on the total deposition rate and on the film uniformity, with the distance of 9.3 mm yielding the thinnest, but most uniform films. No differences were noted with substrate bias so it was also removed early in the experiments.

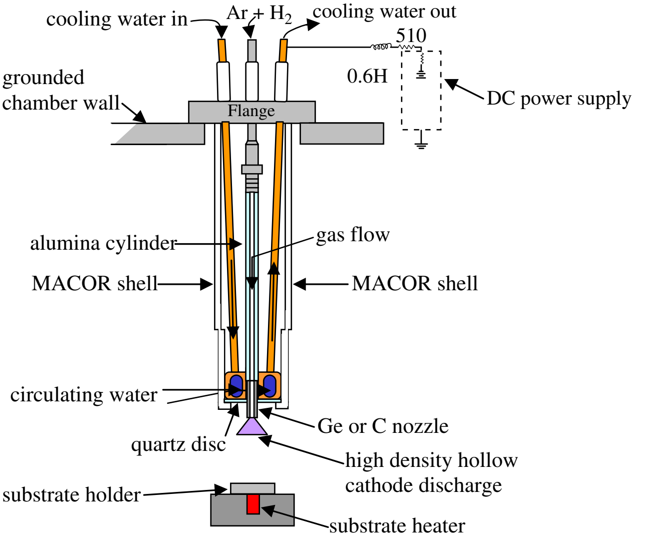

Fig. 1. DC configuration of the hollow cathode plasma-jet with a single nozzle.