

## BRIEF COMMUNICATIONS

### Deposition of Nickel Chalcogenide Thin Films by Solution Growth Techniques

P. PRAMANIK\* AND S. BISWAS

*Department of Chemistry, Indian Institute of Technology,  
Kharagpur 721 302, India*

Received November 22, 1985; in revised form March 10, 1986

#### Introduction

Chemical methods for the preparation of inorganic chalcogenide thin films offer the advantages of economy, conveniency, and large area deposition capability. Solution growth techniques for the deposition of thin films of lead chalcogenides (1-4), bismuth chalcogenides (5-7), etc., have been reported earlier. However, the formation of nickel chalcogenide thin films by chemical processes has not yet been reported. The present communication describes the deposition of NiS and NiSe thin films by solution growth techniques at room temperature (30°C).

#### Experimental Techniques

(a) For the deposition of NiS thin films, 10 ml of 0.8 M nickel sulfate solution was taken in a 100-ml beaker to which 15 ml of 7.4 M triethanolamine and 35 ml of 14 M ammonia solution were added successively. The solution was stirred well so that a homogeneous clear solution is formed. Then 10 ml of 0.8 M thioacetamide solution

was added and total volume was made up to 100 ml by distilled water. A thoroughly cleaned glass slide was placed vertically inside the beaker and the resulting solution was stirred with magnetic stirrer. After about 4 hr, the slide covered with a black deposit was removed, washed with distilled water, and dried in a dessicator. The range of the film thicknesses was from 0.03 to 0.09 μm. The basic chemical reaction that lead to the formation of NiS is as follows:



(b) For NiSe thin films, 10 ml of 0.4 M nickel sulfate solution was taken in a 100-ml beaker to which 10 ml of 7.4 M triethanolamine (TEA), 15 ml of 14 M ammonia solution, and 8.5 ml of 5 M sodium hydroxide solution were added in order. The solution was stirred well so that a clear homogeneous solution was formed. Then 1.7 ml of hydrazine hydrate (80%) was mixed, followed by 10 ml of 0.4 M sodium selenosulfate solution which was prepared by the reported method (5). The resulting solution was made up to 100 ml by distilled water. It was stirred for few seconds by a magnetic

\* To whom correspondence should be addressed.

TABLE I  
X-RAY DATA OF NiS AND NiSe FILMS PREPARED BY  
THE PRESENT METHODS

Observed $d$ values (Å) for NiS	Possible identification with standard $d$ (Å) for NiS	Observed $d$ values (Å) for NiSe	Possible identification with standard $d$ (Å) for NiSe
4.842	(110) 4.81	3.18	(100) 3.20
2.95	(101) 2.946	2.74	(101) 2.73
2.778	(300) 2.78	2.07	(102) 2.04
2.519	(021) 2.513	1.84	(110) 1.825
2.24	(211) 2.228	1.58	(103) 1.551
1.89	(131) 1.8631	1.49	(112) 1.514
1.84	(410) 1.8178	1.341	(202) 1.359
1.715	(401) 1.7372	1.31	(004) 1.336
1.645	(321) 1.6340	1.20	(203) 1.181
1.59	(330) 1.6037	1.159	(211) 1.164
1.55	(012) 1.5470	1.101	(212) 1.089
		1.06	(114) 1.078

stirrer and then poured into another beaker containing a thoroughly cleaned glass slide, clamped vertically. After about 50 min, the slide, covered with a black deposit, was removed, washed with distilled water, and dried in a dessicator. The thicknesses of the

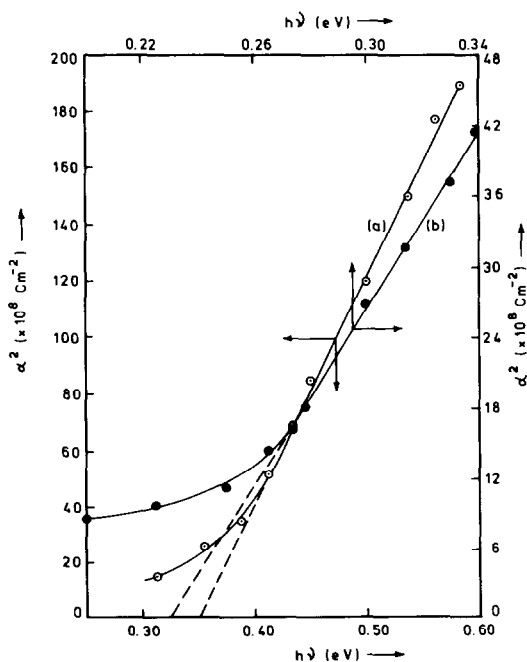
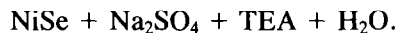
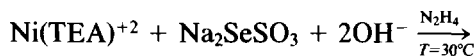


FIG. 1. Optical absorption spectra of (a) NiS thin film, (b) NiSe thin film deposited on calcium fluoride substrate at room temperature (30°C).

films were in the range of 0.06 to 0.25  $\mu\text{m}$ . The basic chemical reaction that led to the formation of NiSe is as follows:



## Results and Discussion

X-ray diffraction data for NiS as well as NiSe reveal that both the films prepared by the present methods are polycrystalline in nature and their observed  $d$  values are in good agreement with the standard values taken from ASTM Diffraction Data File, shown in Table I.

The optical densities of both the films (deposited on calcium fluoride substrate) at various wavelengths, measured by a Beckmann-5270 spectrophotometer, were used to determine the absorption coefficients  $\alpha$  for the samples at various photon energies. A plot of  $\alpha^2$  versus  $h\nu$  for both the films (NiS and NiSe) is shown in Fig. 1. Extrapolation of the linear portions of the curves to  $\alpha^2 = 0$  give the optical band gaps which are 0.35 and 0.23 eV for NiS and NiSe, respectively.

Both the films were found to be  $p$  type in nature by thermoelectric probe methods. The conductivities of NiS films were in the order of  $10^{-1}$  S  $\text{cm}^{-1}$  and that of NiSe film  $10^{+1}$  S  $\text{cm}^{-1}$  measured by four probe methods at room temperature. The current-voltage characteristics of NiS and NiSe films with graphite (Achason DAG-580) contacts were found to be linear, suggesting that graphite paint forms an ohmic contact with both the films. More detailed studies are in progress.

## References

1. J. BLOEM, *Appl. Sci. Res. B* **6**, 92 (1956).
2. H. N. ACHARYA AND H. N. BOSE, *Phys. Status Solidi A* **6**, K43 (1971).
3. T. S. MOSS, *Proc. IRE* **43**, 1869 (1955).

4. D. H. ROBERTS AND J. E. BAINES, *J. Phys. Chem. Solids* **6**, 184 (1958).
5. P. PRAMANIK, R. N. BHATTACHARYA, AND A. MONDAL, *J. Electrochem. Soc.* **127**, 1857 (1980).
6. P. PRAMANIK AND R. N. BHATTACHARYA, *J. Electrochem. Soc.* **127**, 2087 (1980).
7. S. BISWAS, A. MONDAL, D. MUKHERJEE, AND P. PRAMANIK, *J. Electrochem. Soc.*, **133**, 48 (1986).