Effect of annealing on the laser induced photoluminescence behavior of template-synthesized silver iodide nanowires

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Silver iodide nanowires have been fabricated using non-galvanic template synthesis technique. The effect of annealing on the laser induced photo luminescent behavior of silver iodide nanowires has been studied. It is established that due to annealing, emission wavelength of silver iodide nanowires change. In comparison with un-annealed nanowires, the emission wavelength is found to decrease with the increase in annealing temperature and annealing time as well. These studies are very important as silver iodide is a very useful candidate for photography applications.

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1. Introduction

The optical properties of semiconductor micro and nanocrystals are of much contemporary importance as they endow with information about the evolution of physical characteristics from atom to bulk and about the three-dimensional confinement of carriers and excitons [1]. At these dimensions, the size and shape of the particles invariably conclude the amount of confinement and plays a significant role in determining the electronic energy states of the semiconductor. Silver halides have some exceptional features and occupy a significant position in solid state physics because their properties can be measured as of intermediate nature between ionic and covalent bonding. Silver iodide (AgI) is a chemical compound used in photography, an antiseptic in medicine, rainmaking and cloud seeding [2]. AgI is also an ionic direct band gap semiconductor, and has an allowed lowest energy band-to-band transition [3].

'Template synthesis' is a versatile technique to fabricate nanostructures [4]. The technique involves synthesis of desired material within the pores of a membrane (ion track membrane, anodic alumina membranes, zeolites etc.) [5-7]. Materials with nanoscopic dimensions not only have potential technological applications in various areas but also are of fundamental interest as the properties of a material can change in this regime of transition between the bulk and molecular scales. A keen interest is, therefore, being exhibited towards the fabrication of low dimensional materials like metals [8], semiconductors [9-10], polymers [11], etc. The present work reports an indirect method using laser induced photoluminescence for estimating qualitative change in the resistivity of thermally annealed silver iodide (AgI) nanowires. Earlier no researcher has tried this thing however so many researchers have fabricated Silver Iodide nanowires by different routes.

2. Experimental synthesis

Polycarbonate (PC) ion track membranes (ITMs), having pore diameter 100 nm (thickness 6-11 μm) were acquired from Nuclepore, USA. AgI nanowires were fabricated using an acrylic cell comprising of two hollow compartments provided with O-rings on their inner sides to hold the sample between them when the compartments are screwed together. To fabricate AgI nanowires, $AgNO_3$ solution (0.1 M/l) was taken in one compartment and NaI (1.0 M/l) in the other. The solutions were then allowed to permeate through the pores in ITM where the following chemical reaction took place:

$$AgNO_3 + NaI \rightarrow AgI + NaNO_3$$

The silver iodide precipitates in pores. After the completion of the reaction, the solutions were drained out and the ITM, with AgI precipitated into its pores, was taken out, dried in air and gently pasted on an adhesive copper tape. To dissolve the polycarbonate ITM, dichloromethane was used drop by drop leaving behind AgI nanowires having dimensions of the size of the pores in ITM.

2.1. Photoluminescence studies

The silver iodide nanowires were irradiated with ultraviolet (UV) laser light from a Nitrogen laser (power = 10 kW, wavelength = 337.1 nm, pulse width = 5-7 ns). The emission from the nanowires was collected by a fast (2 ns rise time) photomultiplier tube (PMT) through an assembly of monochromator as a wavelength selective element and a glass slab to filter out the UV radiation. The signal from the PMT was fed to a Digital Storage Oscilloscope (Tektronix make TDS-220) interfaced (RS-232) with a computer to record decay curves. To investigate the effect of annealing on emission wavelength of the AgI nanowires, the above process was repeated after thermally annealing the nanowires first for one hour at 80^o C, and then further for another one hour at 120^o C.

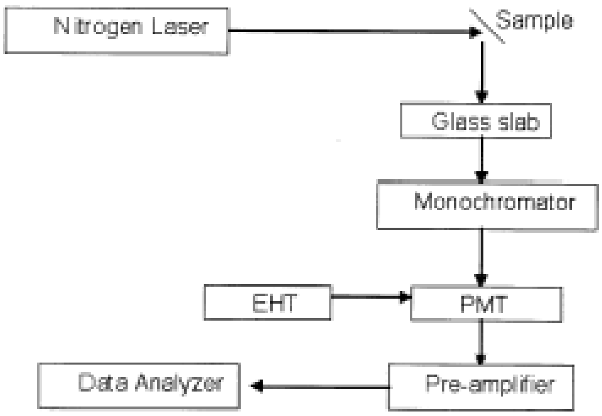

Fig. 1. Photoluminescence setup.

3. Results and discussion

Fig. 1 shows very fine crop of fabricated silver iodide nanowires using electroless deposition. The shine on the surface of silver iodide nanowires shows that they are cathodoluminescent also. The crop of nanowires falls after dissolution of the membrane. The size of the fabricated silver iodide nanowires is around 100 nm as seen in SEM.

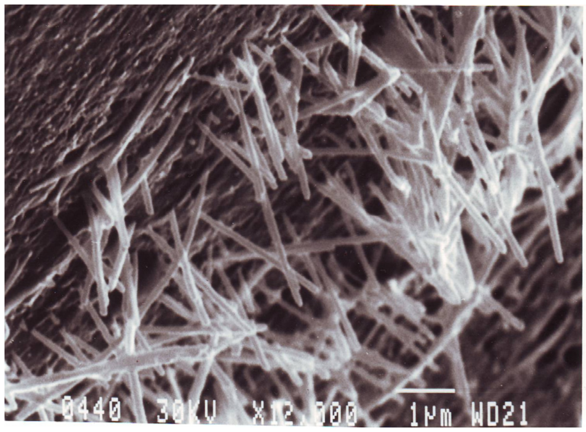

Fig. 2. SEM micrograph of 100 nm silver iodide nanowires.

Table. 1 shows the emission wavelength for un-annealed AgI nanowires; this is 626 nm. On annealing, the emission wavelengths for the silver nanowires are found to shift to the lower wavelength side. Corresponding to temperatures 80° and 120° C, the new emission wavelengths become 560 and 451 nm for AgI nanowires. The decrease in emission peak wavelengths indicates increase in band gaps of the AgI nanowires, i.e. increase in their resistivity.

Table. 1. Annealing time vs. emission wavelength.

Name of compound	Annealing time (hour)	Annealing temperature (^{o}C)	Emission wavelength (nm)
AgI	Unannealed	27° (Room temperature)	626
	1	80°	560
	2	first for 1 hour at 80° and then again for 1 hour at 120°	451

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