Selecting a method for obtaining mercuric iodide nanoparticles

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Abstract
Mercuric iodide (HgI_2) is a compound semiconductor currently developed for application as ionizing radiation detector. The trend in HgI_2 films has been the polycrystalline growth and then the oriented growth. Results showed that the detector performance is better when the crystalline film is oriented. Because of the structure similarity between Inorganic Fullerenes (IF), like MoS_2, $NiCl_2$ and HgI_2, and taking into account the reports of obtaining IF nanostructures, we synthesized mercuric iodide nanoparticles. We will use these nanoparticles in order to obtain a first monolayer of a film; in this way the further film growth should be guided by the monolayer orientation. We look for the best nanoparticle synthesis method among suspension, microwave and hydrothermal ones. X-ray diffraction (XRD), transmission electron microscopy (TEM) and energy dispersive spectroscopy (EDS) results showed that the suspension method is the best to obtain mercuric iodide nanoparticles. TEM results show that the morphology of the nanoparticles that we obtained by this method is adequate to be used as nuclei in the film growth process.

Introduction
Mercuric iodide (HgI_2) is a compound semiconductor that belongs to the layered compounds family MXn (M: heavy metal, X: no metal, n>1); its crystalline planes are perpendicular to the *c* axis, thus they have strong crystallographic, morphologic and other anisotropies. It is this anisotropy which leads the mercuric iodide crystals to growth with "platelet" habit [1]. HgI_2 also has the best properties to act as an ionizing radiation sensor. Moreover, the trend in HgI_2 films has been the polycrystalline growth and then the oriented growth; results showed that the detector performance is better when the crystalline film is oriented [2].
On the other hand, in the last years there has been a great development of nanotubes and nanoparticles similar to fullerenes (inorganic fullerenes (IF)) which are compounds of the NY_2 family such as MoS_2, WS_2, $NiCl_2$ and $CdCl_2$ [3,4]. Because of the structure similarity between IF and HgI_2, we started to synthesize mercuric iodide nanoparticles in order to use them as nuclei to obtain the first monolayer of a film; in this way the further film growth should be guided by the monlayer orientation.

Experimental
We have studied different methods for synthesizing nanoparticles: suspension, microwave and hydrothermal [5,6,7,8]. We studied the influence of different synthesis conditions (solvents, temperatures, iodine source, mercury (II) source, etc.) in each of the three methods in order to obtain mercuric iodide nanoparticles of adequate morphology for oriented nucleation. Table 1 shows such conditions.

Method	SUSPENSION	MICOWAVE	HYDROTHERMAL
Solvent	Octadecene	Ethyleneglycol (EG) Ethanol	$EG+H_2O$+Urea $EG+ H_2O+NaOH$ $EG+H_2O+HNO_3$ H_2O
Mercuric source	$Hg(NO_3)_2H_2O$	$Hg(NO_3)_2H_2O$	$Hg(NO_3)_2H_2O$
Iodine source	I_2(s), KI, NaI	KI/I_2(s)	NaI/KI
Temperature (ºC)	Initial: 50-90 Final: 90-110	190 (5 atm)/100 (15 atm)	120 (furnace)

Table 1. Conditions used in the different mercuric iodide nanoparticles synthesis methods

Results and discussion

For all the synthesis methods, mercuric iodide identity in the obtained nanoparticles was first checked by X-ray diffraction. We did not obtain mercuric iodide by microwave and hydrothermal methods. The XRD diffractogram showed in Figure 1 confirms HgI_2 identity for the compounds obtained by suspension method.

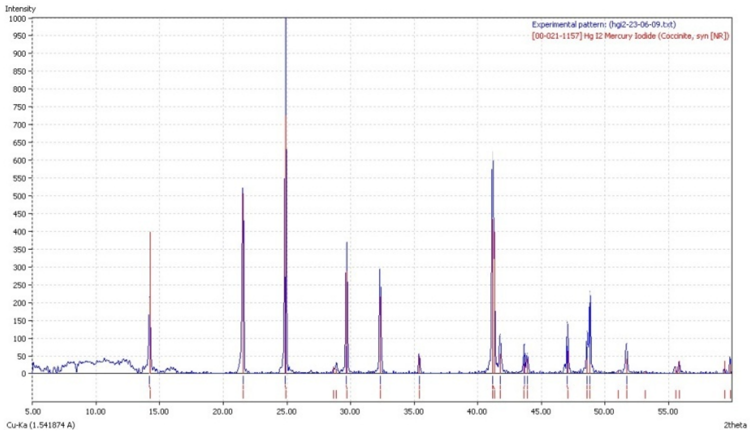

Figure 1. X-ray Diffractogram of HgI_2 nanoparticles

The conditions used to synthesize mercuric iodide disc-like nanoparticles by the suspension method were the following: octadecene as solvent, 70ºC as initial temperature (10 minutes), 110ºC final temperature (2 hours) and I_2 as iodine source. HgI_2 nanoparticles were then centrifugated and washed with ether.

The nanoparticles synthesized by the suspension method were observed by Transmission Electron Microscopy (Jeol 2100 MSC). Images of the obtained disk-like nanoparticles are depicted in Figure 2. Nanoparticles diameter ranges between 80 and 400 nm. Energy Dispersive Spectroscopy was performed to the disk-like nanoparticles in order to bear out the compound identity; Figure 3 shows an EDS diagram of one of the nanodiscs showed in Figure 2.

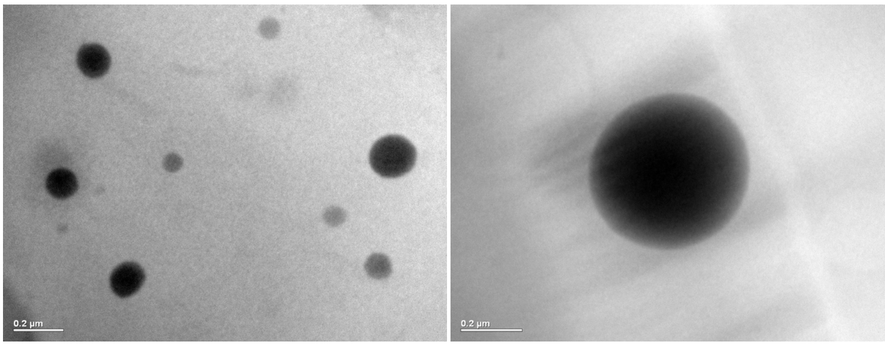

Figure 2. Transmission electron micrographs of HgI_2 disk-like nanoparticles kV= 200 keV

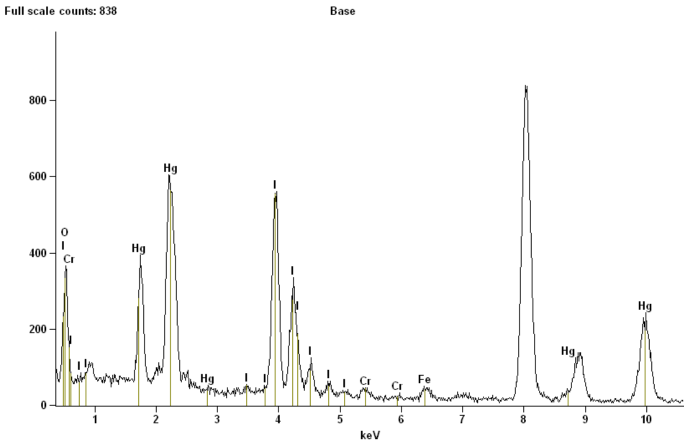

Figure 3. EDS Spectrum of one of the disk-like nanoparticle showed in Figure 2.

Conclusions

We obtained mercuric iodide nanoparticles by the suspension method. Microwave and hydrothermal methods have to be improved in orden to synthesize mercuric iodide nanoparticles. It is the first time that mercuric iodide disc-like nanoparticles are obtained by a suspension method. This method is also satisfactory to obtain nanoparticles of adequate morphology to be employed in compound semiconductors monocrystalline film growth.

Acknowledgements: Authors thank the Laboratorio de Microscopia Electronica (LME), Centro Nacional de Pesquisas em Engeria e Materiais (CNPEM), and Prof. Dr. Jesiel Freitas Carvalho, Grupo de Física de Materiais, Universidad Federal de Goias, for the use of the TEM and for the XRD measurements respectively.

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