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ELECTROCHEMICAL SYNTHESIS OF BRANCHED $Al_xGa_{1-x}As$ NANOWIRES

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INTRODUCTION

Multilayer nanostructures have found wide applications in various industries. Recently, most research efforts have focused on obtaining controllable three-dimensional nanostructures. Such structures are characterized by a pronounced morphology and a large specific surface. So, they have excellent properties.

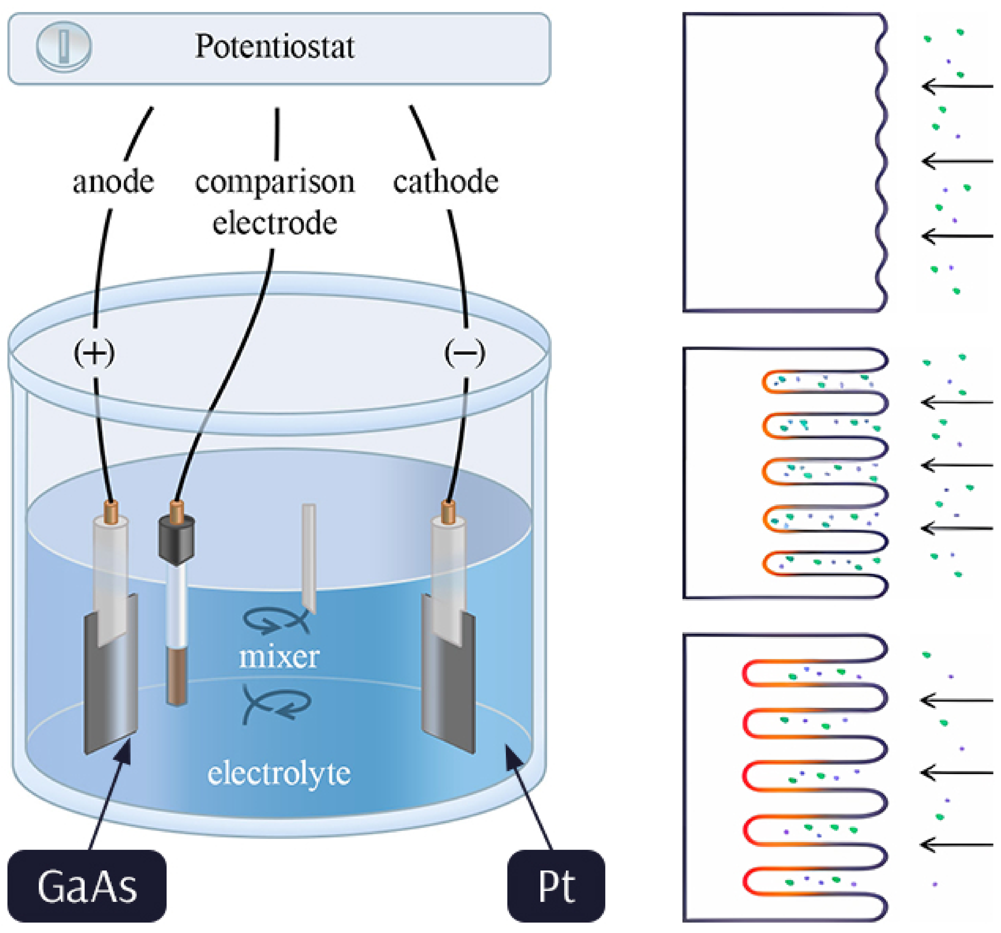
In this study, we have reported on the synthesis of $Al_xGa_{1-x}As$/por-GaAs/GaAs heterostructure by combining several electrochemical methods: electro-chemical etching and electrochemical deposition.

EXPERIMENT

Step 1: Formation of a porous layer on the mono-GaAs surface

We use the method of electrochemical etching to synthesize porous layers on the surface of semiconductors.

A semiconductor is immersed in an electrolyte and subjected to the influence of an electric current. This leads to the semiconductor's dissolution and forming a porous layer.



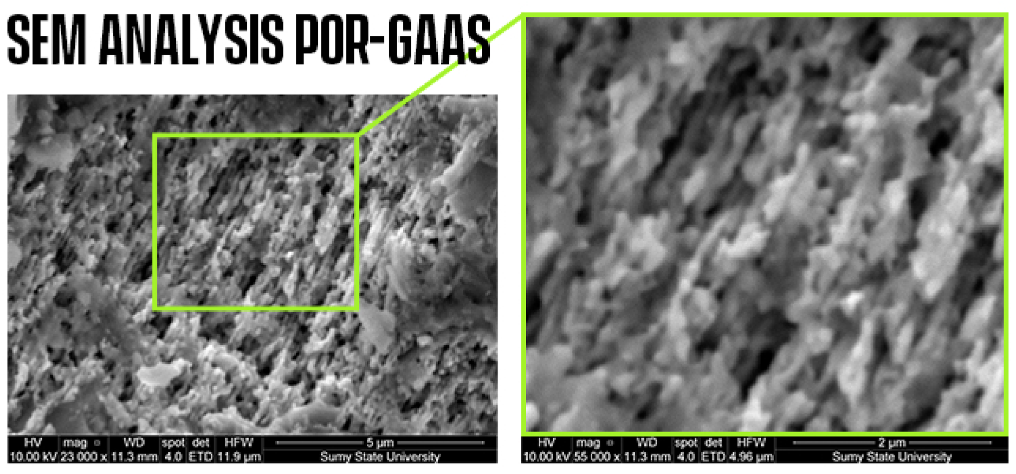
Benefits of electrochemical etching:

- Simple
- Non-vacuum
- Affordable
- Quick
- Large-area coverage
- Scalable

Conditions of the experiment:

- Electrolyte: HCl:H2O=1:4
- U = 4 V
- t = 6 min

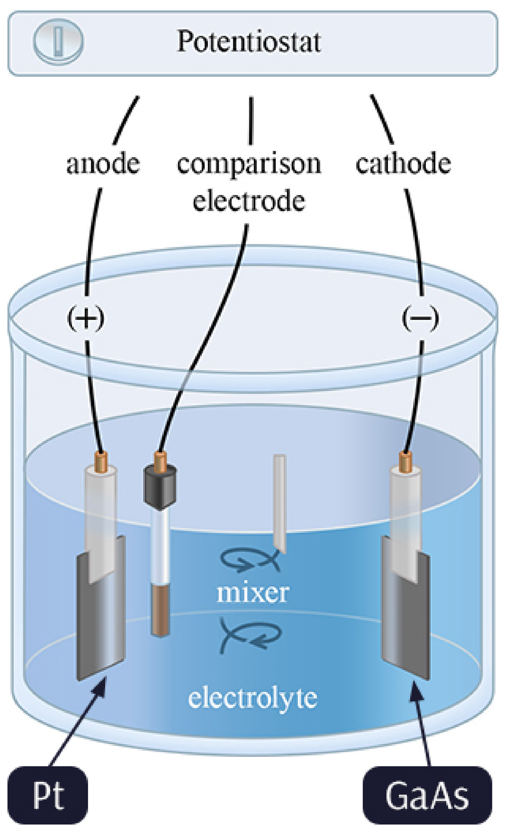
SEM ANALYSIS POR-GAAS



SEM image of the surface of porous GaAs after electrochemical etching

EXPERIMENT

Step 2: Electrochemical deposition of $Al_xGa_{1-x}As$ in por-GaAs/GaAs



$Al_xGa_{1-x}As$ was deposited on the por-GaAs/GaAs surface in the same electrolytic cell.

The cathode and anode switched places.

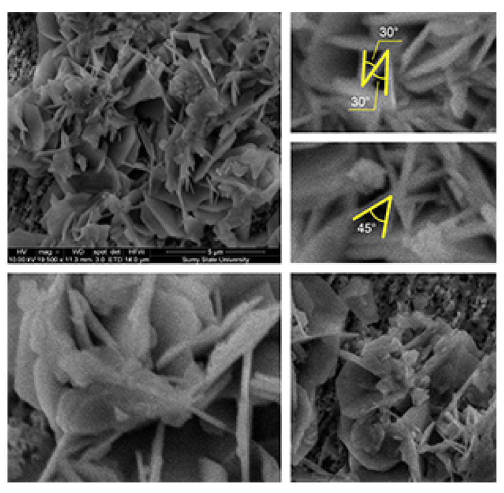
We used an aqueous solution of aluminum chloride ($AlCl_3$).

Three processing cycles were carried out.

Conditions of electrochemical deposition of $Al_xGa_{1-x}As$ on por-GaAs/GaAs

Cycles	Conditions of electrochemical deposition		
	Electrolyte	Processing time, min	Voltage, V
Cycle 1	$AlCl_3$	3	3
		1	7
Cycle 2		3	3
		1	7
Cycle 3		3	0

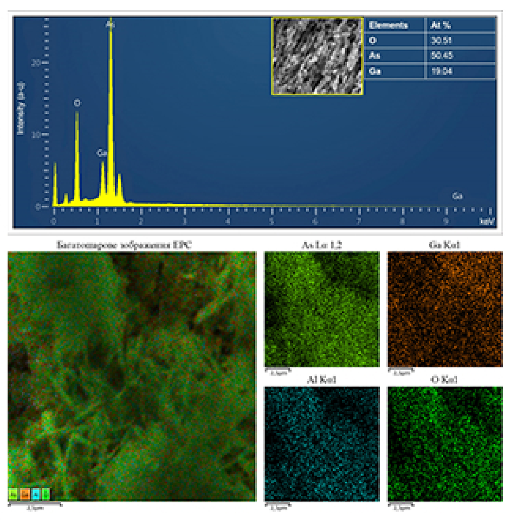
SEM analysis $Al_xGa_{1-x}As$/por-GaAs/GaAs



SEM image of heterostructure $Al_xGa_{1-x}As$/GaAs

"Desert Rose" mineral

EDX analysis

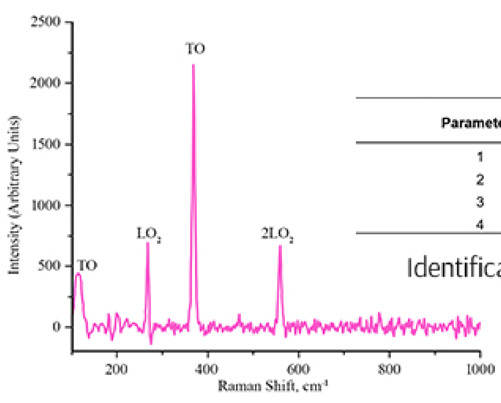


Elements	At, %			
	1	2	3	4
O	7.35	6.23	7.01	6.91
As	41.54	42.12	40.69	42.05
Ga	26.74	26.95	26.51	27.14
Al	24.37	24.7	25.79	23.90
Total	100	100	100	100

Elemental composition of the $Al_xGa_{1-x}As$ surface, obtained using the EDX method

Elements	Relative units, %			
	1	2	3	4
Ga/As	0.64	0.64	0.65	0.65
Al/As	0.59	0.59	0.63	0.57
Al/Ga	**0.911**	**0.916**	**0.973**	**0.881**
(Al+Ga)/As	1.23	1.23	1.28	1.22

The ratio of components on the surface $Al_xGa_{1-x}As$

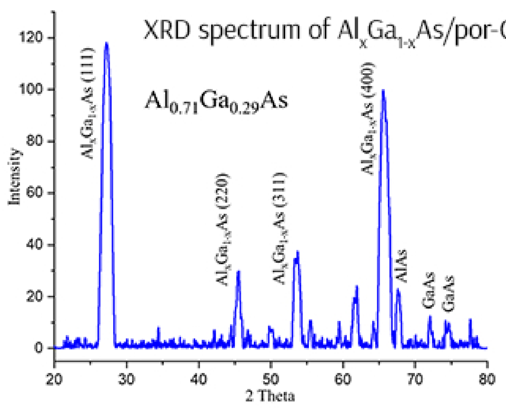


Parameters	Identification		
	Raman shift	Phonon mode	Assignment
1	110	TO	Ga-As, Al-As
2	267	LO_2	Ga-As
3	369	TO	Al-As
4	559	$2LO_2$	Ga-As

Identification of Raman spectrum peaks $Al_xGa_{1-x}As$

Raman analysis

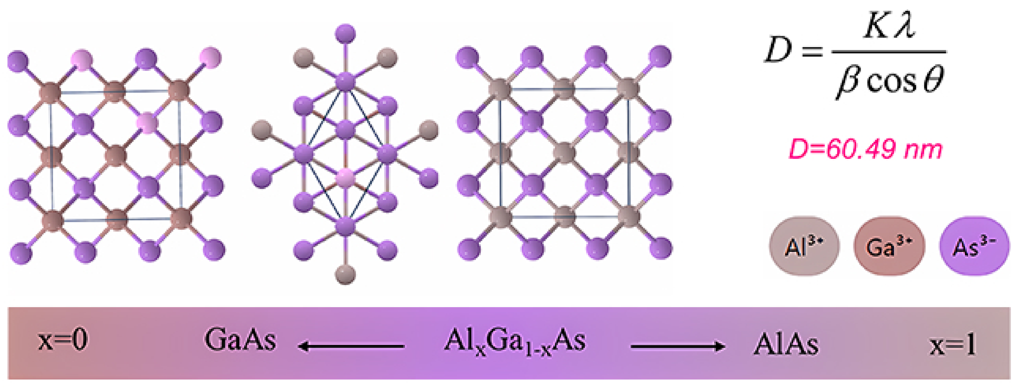
XRD spectrum of $Al_xGa_{1-x}As$/por-GaAs/GaAs heterostructure



№	2θ, °	hkl	Crystal	Crystal system
1	27.25	(111)	AlAs	Cubic
2	31.57	(200)	$Al_{0.71}Ga_{0.29}As$	
3	45.26	(220)		
4	53.65	(311)		
5	56.25	(222)		
6	65.96	(400)	GaAs	

Crystal Structures Determined by XRD

XRD- analysis

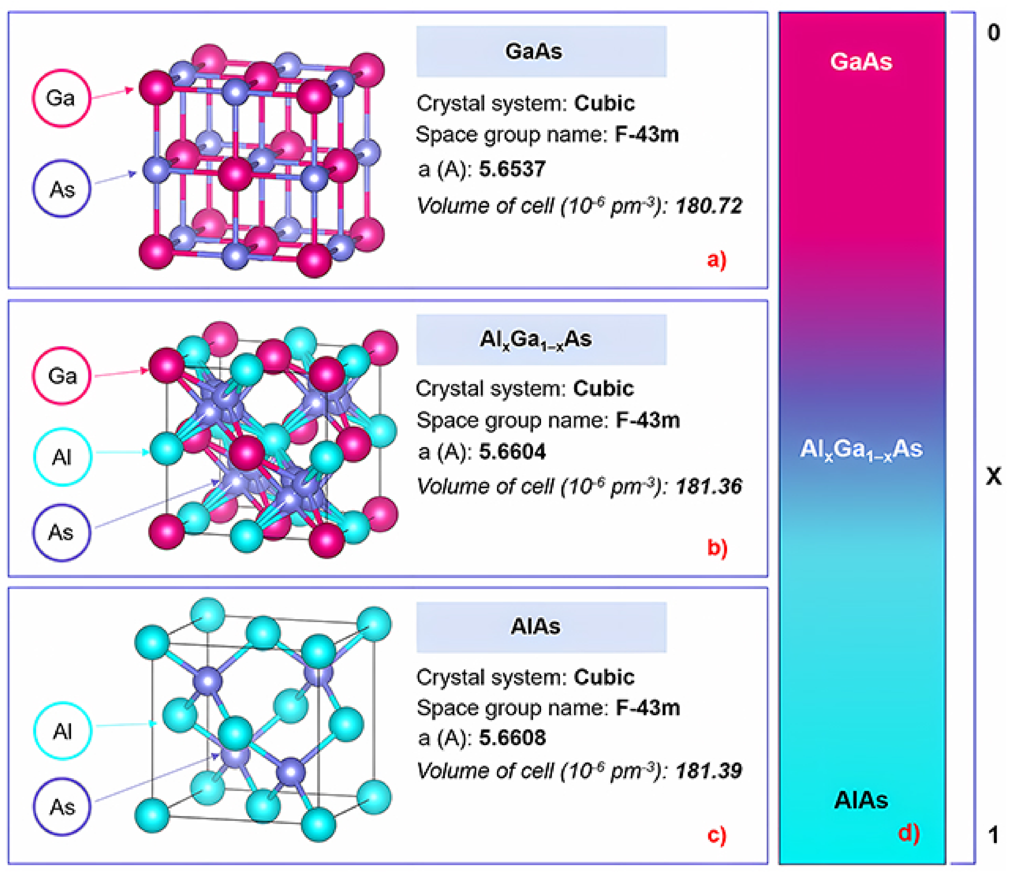


$$D = \frac{K\lambda}{\beta \cos\theta}$$

D=60.49 nm

RESULTS AND DISCUSSION

So, the top layer is represented by 'Desert Rose Stone"-like crystallites $Al_xGa_{1-x}As$. Crystals AlxGa1-xAs are a triple compound, the proportion of components of which depends on coefficient x.
When x = 0, there is a transition to GaAs, and when x = 1, the AlAs compound is formed. The parameters of the lattices $Al_xGa_{1-x}As$, AlAs, and GaAs show excellent consistency. This shows that gallium arsenide is the best substrate for forming $Al_xGa_{1-x}As$ layers.

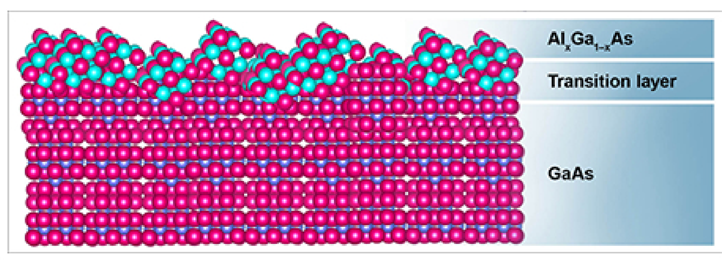


Crystal lattices and structural parameters of GaAs (a), $Al_xGa_{x-1}As$ (b) and AlAs (c), respectively, and the ratio of Al and Ga elements in the semiconductor $Al_xGa_{x-1}As$ (d)

CONCLUSION

This report demonstrated a method for obtaining the $Al_xGa_{1-x}As$/por-GaAs/GaAs heterostructure with "Desert Rose Stone"-like nanocrystallites. Combined electrochemical methods formed the structures.
As follows from the above, such structures with a developed morphology demonstrate several advantages for their further use in solar cells due to their features: the rough substrate provides the absorption of more photons; a large specific surface area reduces optical losses.

In turn, the structure $Al_xGa_{1-x}As$/por-GaAs/GaAs, as shown above, complies in full with the parameters of the crystal lattices of the components, which reduces the values of the thermal expansion coefficients. Furthermore, photon absorption by the structure with 'Desert Rose Stone"-like crystallites becomes even more efficient due to the various directions of the petals.



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