Effect of thickness on the formation of grain boundary joints in undoped silicon films with a fibrous structure

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Introduction

The structure of silicon films is the object of extensive research, since it has a great influence on the stability and reliability of devices in which silicon is used [1]. Characteristic elements of the silicon film structure that affect the properties of the films are grain boundary joints. But these studies do not give an idea of the role of film formation conditions and subsequent technological treatments in the formation of one or another type of grain boundary joints.

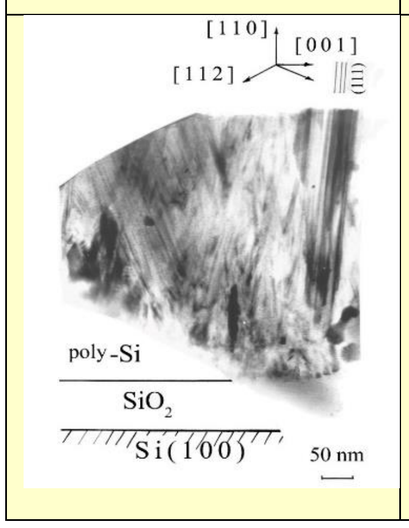
The aim of this work is to study the mechanisms of the formation of grain boundary joints in fibrous undoped silicon films of various thicknesses.

Experimental

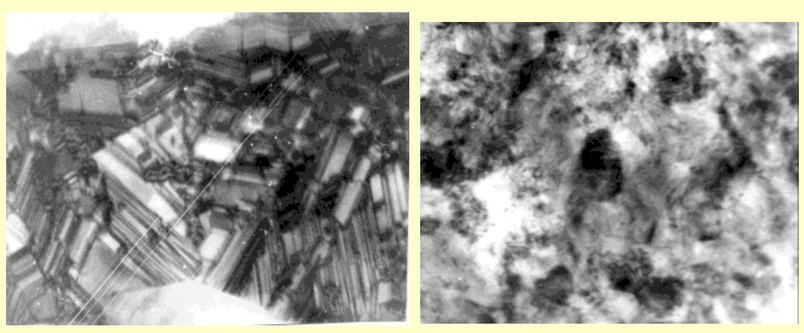
Silicon films were obtained by low-pressure chemical vapor deposition on thermally oxidized (100 nm oxide thickness) (100) Si wafers. The deposition temperature was equal to 630^{0}C. The film thickness was ranged from 85 nm to 1500 nm. The structure of the films was studied by transmission electron microscopy. Surface morphology was analyzed by atomic force microscopy.

Results

Cross-section TEM image of an undoped polysilicon film



Plan-view TEM images of the structure of undoped polysilicon films of different thicknesses: a - 85 nm, b - 150 nm



50 нм ---- -25 нм ____

a b

The relative amounts of different types of grain boundary joints depending on the film thickness

Film thick-ness, nm	Grain boundary joints, % (AFM Examples and Schematics)						
	Triple			Multiple			
	3a	3b	3c	4a	4b	4c	5
	16,2	54,1	18,9	4, 0	6, 8	-	
100	25	41,7	20,8	4,2	8,3	-	-
500	63,7	20,3	3,8	1,2	5,2	4,5	1,2
1500	63,0	20,4		1,2	5,9	4,4	0,89

____ - grain boundaries of the general type,
------- - special grain boundaries

Conclusion

1.In undoped polysilicon films, both triple and multiple junctions of grain boundaries of different types are observed, the ratio of which is determined by the film thickness.

2. Twinning processes that occur during film growth play a leading role in the formation of the fibrous structure of undoped polysilicon films. It is assumed that the migration of grain boundaries is a mechanism for the growth of twin complexes with increasing film thickness.

3. The relaxation of internal stresses, which occurs due to the transition from low-angle grain boundaries to high-angle grain boundaries, can be considered as the driving force for the rearrangement of the system of grain boundaries during film growth.

4. Multiple junctions of grain boundaries occur in films through such mechanisms as multiple twinning, splitting of grain boundaries, interaction of $\sum 3^n$ boundaries during film growth, and faceting of grain boundaries.

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References

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