Low temperature ECR-PECVD microcrystalline SiC growth by pulsed gas flows

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Abstract: Thin SiC layers have been grown by ECR-PECVD on (100) Si substrates at substrates temperatures of 850°C and low pressure (mTorr). SiH_4 and CH_4 were used as precursor gases, added to a continuous Ar flow that maintains a stable plasma all over the process. One or both precursor gases were pulsed in order to perform a layer-by-layer growth. Different conditions and flow ratios have been used, while maintaining the microwave power fixed. Previous carbonization of the silicon surface has been also investigated and the presence of plasma during this step is discussed. Composition and effective thickness of the samples has been determined by FTIR and spectroscopic ellipsometry. AFM measurements reveal the presence of ordered microcrystals under certain process conditions of carbonization and growth. These crystals with an apparent cubic structure have average height and diagonal length of about 16nm and 330nm respectively, from the focused analysis of one of them. Its density seems to be related to the carbonization pre-process.

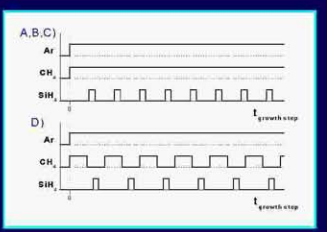
Purpose of the work:

To reduce the SiC growth temperature taking advantage of the high density of ions and radicals generated in ECR plasmas.
Films grown under continuous gas flows shown amorphous structure, as was observed in previous experiments.
In this work, pulsed precursor-gas flows in Ar maintained plasmas are investigated as growth processes.

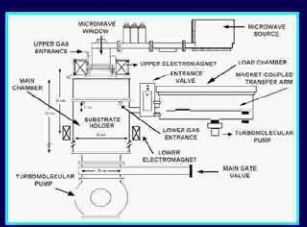
Experimental conditions:

Reference	Carbonization	Growth
A	No	Continuous CH_4 Pulsed SiH_4
B	CH_4 flow	Continuous CH_4 Pulsed SiH_4
C		Pulsed CH_4 &SiH_4
D	CH_4 plasma	Continuous CH_4 Pulsed SiH_4

Growth schemes:



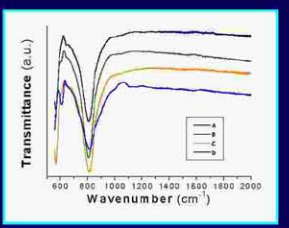
Growth system:



FTIR analysis: SiC band

FWHM of samples A, B and C are similar, but $FWHM_B < FWHM_A < FWHM_C$
FWHM value of sample D is about 42~58% wider than the others

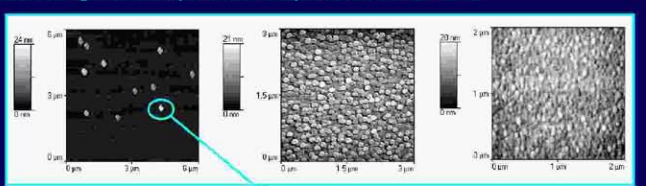
Best conditions:
- Carbonization under CH_4 flow
- Growth: continuous CH_4 flow



Ellipsometric measurement fittings:

Reference	Effective thickness	Composition
A		
B	~135Å	100% SiC
C		
D	198Å	65%SiC + 21% voids + 14% graphite

AFM images of samples without plasma carbonization:



Conclusions:

- Thin SiC layers have been grown by ECR-PECVD on (100) Si at 850°C under pulsed gas flows and pressures of mTorr
- CH_4 plasma presence at the temperature ramp, as a carbonization step, results in graphitic phase appearance
- SiC growth takes place in two different ways depending on the presence or not of CH_4 during the temperature ramp:
  - In absence of CH_4, the growth corresponds to a mainly homogeneous SiC layer with few nucleation structures
  - With CH_4 presence growth by nucleation is enhanced
- Pulsing CH_4 during the growth step results in a softening of the structure edges

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