Higher harmonic frequencies in capacitive discharges and their using for monitoring of plasma processing

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Waveforms of RF voltage
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Simple model of plasma sheath

For constant concentration of electrons:

\[ j = ne \frac{dD}{dt} \]  \hspace{1cm} (1)

\[ u = \frac{ne}{2\varepsilon_0} D^2 \]  \hspace{1cm} (2)

\[ j = -D_0 ne \omega \sin(\omega t) \implies D = D_0(1 + \cos(\omega t)) \]

\[ u = \frac{ne}{2\varepsilon_0} D_0^2 (1 + \cos(\omega t))^2 \propto (1 + 2\cos(\omega t) + \cos^2(\omega t)) \]

\[ \cos^2\omega t = 1 + \cos2\omega t \]
Waveforms of RF voltage

\[ U(t) = U_0 + \sum_{n=1}^{\infty} U_n \cos(n\omega t - \varphi_n) \] (3)
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Plasma etching: End-point detection.

**Figure:** Fundamental harmonic

![Graph showing fundamental harmonic over time](image-url)
Monitoring of deposition and etching

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Detection of dust - 3\(^{th}\) harmonic

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Simulation of higher harmonics

Higher harmonic frequencies in capacitive discharges and their use.
Thank you for your attention