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CALCULATION OF THE ELECTRIC FIELD ON THE ELECTRODE SURFACE WITH DIELECTRIC FILM IN PLASMA *)

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When metals are exposed to plasma, dielectric films and microinclusions on the surface can play a significant role in the nature of the interaction. The presence of dielectric films becomes important in conditions where the metal serves as a cathode when exciting various types of discharges. The purpose of the work is to calculate the electric fields both inside the dielectric film located on a high-potential negative metal electrode, and in its rupture when interacting with the flow of external plasma. A dielectric film, tightly adjacent to the metal surface, is represented as an electric capacitor with charge leakage, which is caused by the electrical conductivity of the dielectric, while the potential of the film surface before the appearance of plasma is equal to the negative potential of the electrode. The film charging process is described by the following equation $U(t) = j_0 \cdot R\left[1 - \exp(-\frac{t}{CR})\right]$, where the change in time t of the voltage U(t) between the outer surface of the dielectric film and the metal, C is the specific electrical capacitance of a unit surface of the dielectric film relative to the metal surface, R is the specific ohmic resistance of a unit area of the film due to electric current leakage, j0 is the ion current from plasma to film surface. As the surface of the film is charged by the flow of ions, the potential of the film surface will increase from an initial negative value Ψ0≈300 V to a more positive value, and the current of electrons from the plasma will also increase. When the total current of ions and electrons on the surface of the film amounts to zero current, the stage of establishing a floating potential Ψf on the surface of the film will begin, i.e. $U(t \to \infty) = \Psi(t \to \infty) - \Psi_0 = j_0 \cdot R = \Psi_f - \Psi_0$. The magnitude of the maximum electric field Ed=(Ψf − Ψ0)/d in a dielectric film in plasma with a duration t≈τpl>>τf=CR. The Table presents the calculated values of the electric field E=U(τf)/d inside oxide films with a thickness of 10-100 nm on titanium. The effect of plasma with a density of 1013–1012 cm-3 on titanium with oxide films 10–100 nm thick leads to the appearance in the film of strong electric fields of 30-3 MV/cm, sufficient for electrical breakdown both inside the film and in its rupture and further to excite various types of discharges. Electric fields inside the film and in its discontinuities are two orders of magnitude higher than the electric fields on pure metal [1].

n_e, cm^{-3}	*d*, nм	*R*, Ohм	C, μF	τ_f=*CR*, μs	j_0, A/ cm^2	U(τ_f), V	E, MV/cm
10^{13}	10	1	20	20	30	30	30
10^{13}	100	10	2	20	30	300	30
10^{12}	10	1	20	20	3	3	3
10^{12}	100	10	2	20	3	30	3

References

[1]. V.A. Ivanov Electric Field on the Surface of a Metal Electrode Immersed in Plasma at a High Negative Potential // Plasma Physics Reports, 2023, Vol. 49, No. 2, pp. 284–289. DOI: 10.1134/S1063780X22601365

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