



Effect of annealing on the optical properties of TiO₂ films

Oleg Prikhodko*, Svetlana Mikhailova **, Yerzhan Mukhametkarimov, Suyumbika Maksimova,
Kuanysh Dauitkhan, Ulantai Doseke

NNLOT, al-Farabi Kazakh National University, 71 al-Farabi avn. 050040 Almaty, Kazakhstan

*E-mail: prikhodko_o@mail.ru

**E-mail: skysvetik91@mail.ru

In this work, TiO₂ films, which were obtained by ion-plasma high-frequency magnetron sputtering of a polycrystalline rutile target in an argon atmosphere at 1 Pa pressure were studied. The TiO₂ films were annealed for 1 hour in air in the temperature range from 100 °C to 400 °C with 100 °C increment. It was found that the TiO₂ films have high transparency, which remains almost unchanged during annealing. The fundamental absorption edge of the films, which is located from 320 to 380 nm, also changes slightly with increasing annealing temperature up to 400 °C.

The refractive index $n(\lambda)$ of the films decreases with incident radiation increasing and, as a result, TiO₂ films are characterized by normal dispersion. With increasing annealing temperature, the refractive index n in the long-wavelength region of the spectrum increase in comparison with those in films without annealing.

When comparing the calculated values of $n(\lambda)$ with theoretical values, one can see that in the short-wavelength region of the spectrum, the dependences $n(\lambda)$ coincide, while discrepancies are observed with wavelength increasing. This may be due to the structural features of the films, which depend on their thickness. In a literature, the refractive index of titanium dioxide was measured for samples with ~ 1-2 μm thickness, while in this work the films with ~ 270 nm thickness were studied.

From the calculated $n(\lambda)$, we can conclude that for TiO₂ films the optical properties are stable up to a temperature of 600 °C. It was found that the absorption laws are equally well satisfied for the studied TiO₂ films before and after annealing. This means that for TiO₂ films before and after annealing at 400 °C, the realization of direct and indirect optical transitions upon absorption of light quanta is equally probable. Optical band gap of the films annealed at 400 °C, determined from the quadratic absorption law, was ~ 3.01 eV, which is typical for TiO₂ films with a rutile structure. This E_g is significantly less than the value obtained using the law with $\gamma = 1/2$, which corresponds to the allowed direct-gap optical transitions.

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References

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