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Plasmonic characterization of titanium nitride films under low temperatures

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Abstract— Titanium nitride (TiN) is a plasmonic material that has recently gained attention due to similar optical properties to gold, however with the advantages of having a high melting point and being CMOS compatible [1]. Some of its applications include biosensing [2] and metamaterials fabrication. In order to broaden its use and integrate it with the field of quantum photonics, it becomes necessary to understand its optical properties at cryogenic temperatures. Through the retrieval of the complex permittivity [3] unveiled from reflection measurements, we were able to analyze the plasmonic properties of a 100 nm thick TiN film, submitted to cryogenic temperatures, down to 1.5 K, in the visible range (650 – 900 nm). We observed that the permittivity of the TiN film has an epsilon-near-zero (ENZ) wavelength [4] of approximately 680 nm, and that around this wavelength the Q factor of localized surface plasmons (Q_{LSPR}) is enhanced with the decrease of temperature, whereas the propagation length of SPPs (L_{SPP}) decreased, as shown in Fig. 1. This means that at the lowest temperature (1.5 K) TiN exhibits good localization of the electric field and combined with its behaviour around the ENZ wavelength, it may be integrated to enhance quantum emitters performance. On the other hand it has poorer propagation properties when compared to noble metals, such as silver or gold, which represents an obstacle for energy transfer.

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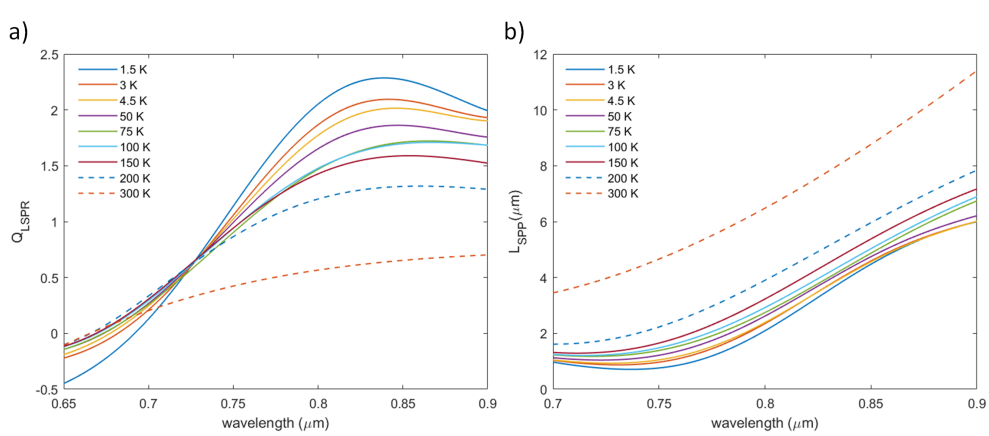

Figure 1: Plots of (a) the Q factor of localized surface plasmons (LSPR) and (b) the propagation length (L_{SPP}) of SPPs, as a function of wavelength for different temperatures.