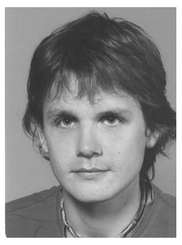

MEDNARODNA PODIPLOMSKA ŠOLA JOŽEFA STEFANA

JOŽEF STEFAN INTERNATIONAL POSTGRADUATE SCHOOL

Ferroelectric Thin Films for Tunable Microwave Applications

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Technology Background

- Microwave technologies are the basis of modern wireless communication systems.

- Ferroelectrics are attractive for microwave devices due to:
  - strong electric field dependence of dielectric permittivity ε'
  - low microwave dielectric losses $tan\,\delta$

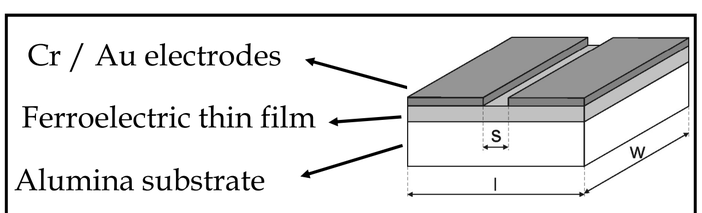
- Ferroelectric thin films technology offers advantages such as:
  - miniaturization of microwave components
  - low operating voltages
  - integration into electronic circuits

Key functional property

$$n_C = \frac{C(0)}{C(E_{max})}$$

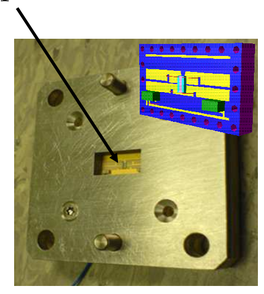
n_C…capacitance tunability
$C(0)$...capacitance at zero applied electric field
$C(E_{max})$…capacitance at selected electric field

Application: phase shifters in electronically steerable antennas*

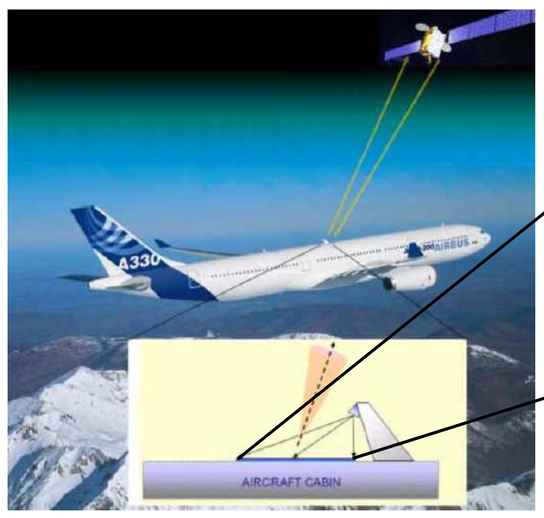


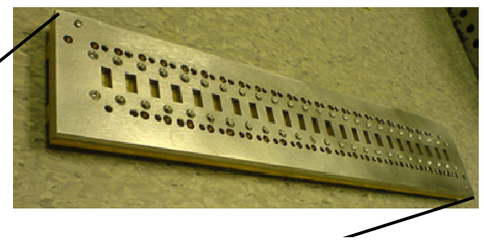
w = 750 µm
l = 1.5 mm
s = (2 – 3) µm ± 0.25 µm

Planar capacitor based on ferroelectric thin film which is used as a phase shifter.



Phase shifter connected to the electronic circuit and mounted into metal housing.





1D phased array based on ferroelectric phase shifters

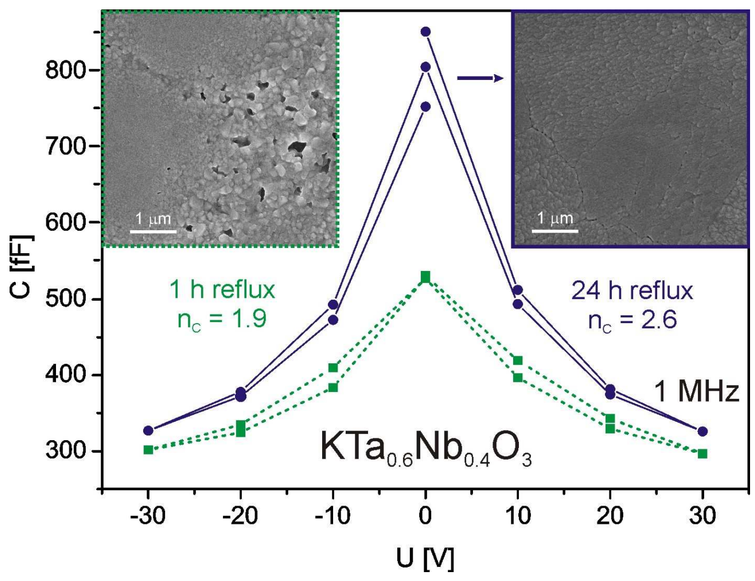
- Because of the geometry these antennas are convenient for aeronautical applications.

*Developed in collaboration with Thales (France), EPFL (Switzerland), and HYB (Slovenia), RETINA (EC 6FP).

Research Activities

Fast development of the communication systems stimulates the research of alternative materials. $K(Ta, Nb)O_3$ solid solution is a promising candidate, however, scarce literature data on preparation and dielectric properties exist.

- **Homogeneous microstructure and strongly enhanced tunability (n_C) were obtained by prolonged reflux time.**



Processing control

Materials composition

Films prepared from the 24 h-refluxed sols.

Composition	ε′ (1 MHz)	n_C (1 MHz)	ε′ (~9.7 GHz)	tanδ (~9.7 GHz)
$KTa_{0.6}Nb_{0.4}O_3$	2200	2.6	675	0.38
$KTa_{0.8}Nb_{0.2}O_3$	375	1.25	690	0.033
$KTaO_3$	190	1.01	220	0.017

- **Dielectric properties are tuned through the Ta / Nb ratio.**

Chemical Solution Deposition of the Films

KOAc, $Ta(OEt)_5$, and $Nb(OEt)_5$ were dissolved in 2-methoxyethanol.

↓

Reactions were performed with different reflux times; by-products were removed by a distillation.

↓

0.4 M sols were deposited on the alumina substrates by spin-coating.

↓

App. 200 nm thick perovskite films were obtained after four sol depositions and heating at 900 °C for 15 min in an RTA furnace.

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