



PERMITTIVITY MEASUREMENTS OF SOIL WITH A CAPACITIVE SENSOR



Stefano Ferraris ⁽¹⁾ and Patrizia Savi ⁽²⁾

⁽¹⁾ Interuniversity Department of Regional and Urban Studies and Planning (DIST), Politecnico e Università di Torino, viale Mattioli 39, 10125 Torino, e-mail: stefano.ferraris@unito.it

⁽²⁾ Dipartimento di Elettronica e Telecomunicazioni, Politecnico di Torino, Italy, e-mail: patrizia.savi@polito.it

ABSTRACT

The determination of permittivity of sand and clay soil over a wide frequency band can be useful in several applications. Fringing Capacitive sensors can be used to measure the real and imaginary part of the permittivity of materials in the RF and microwave frequency bands.

In this work the use of a commercial capacitive sensor has been exploited in order to characterize sand and clay soils with different water content. Liquid and granular materials are particularly suited for this kind of sensor because the sensor can be dipped into the sample thus avoiding contact problems between the surface of the sensor and the material as for solid.

1 Permittivity determination: different methods

FREQUENCY DOMAIN METHODS

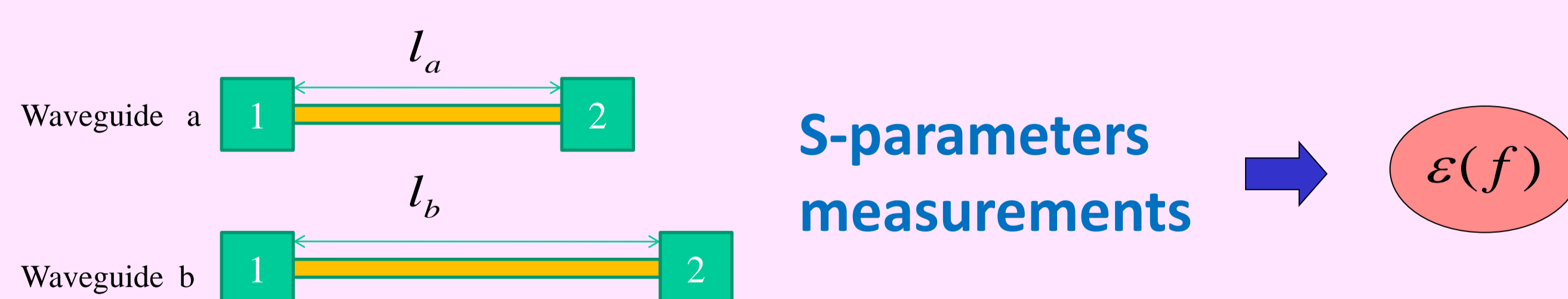
- Open-Ended Coaxial Probe Technique
- Cavity Perturbation Method
- Transmission/Reflection Method
 - Coaxial Line
 - Waveguide



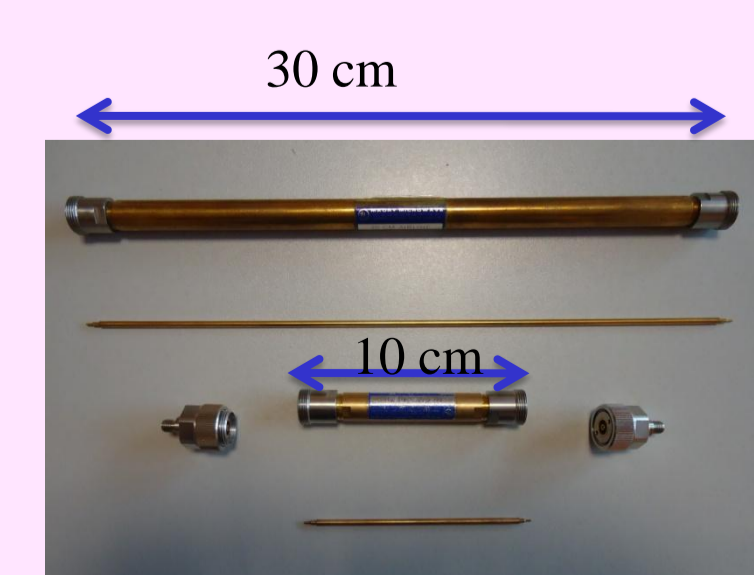
TIME DOMAIN METHODS

- Time Domain Reflectometry (TDR)

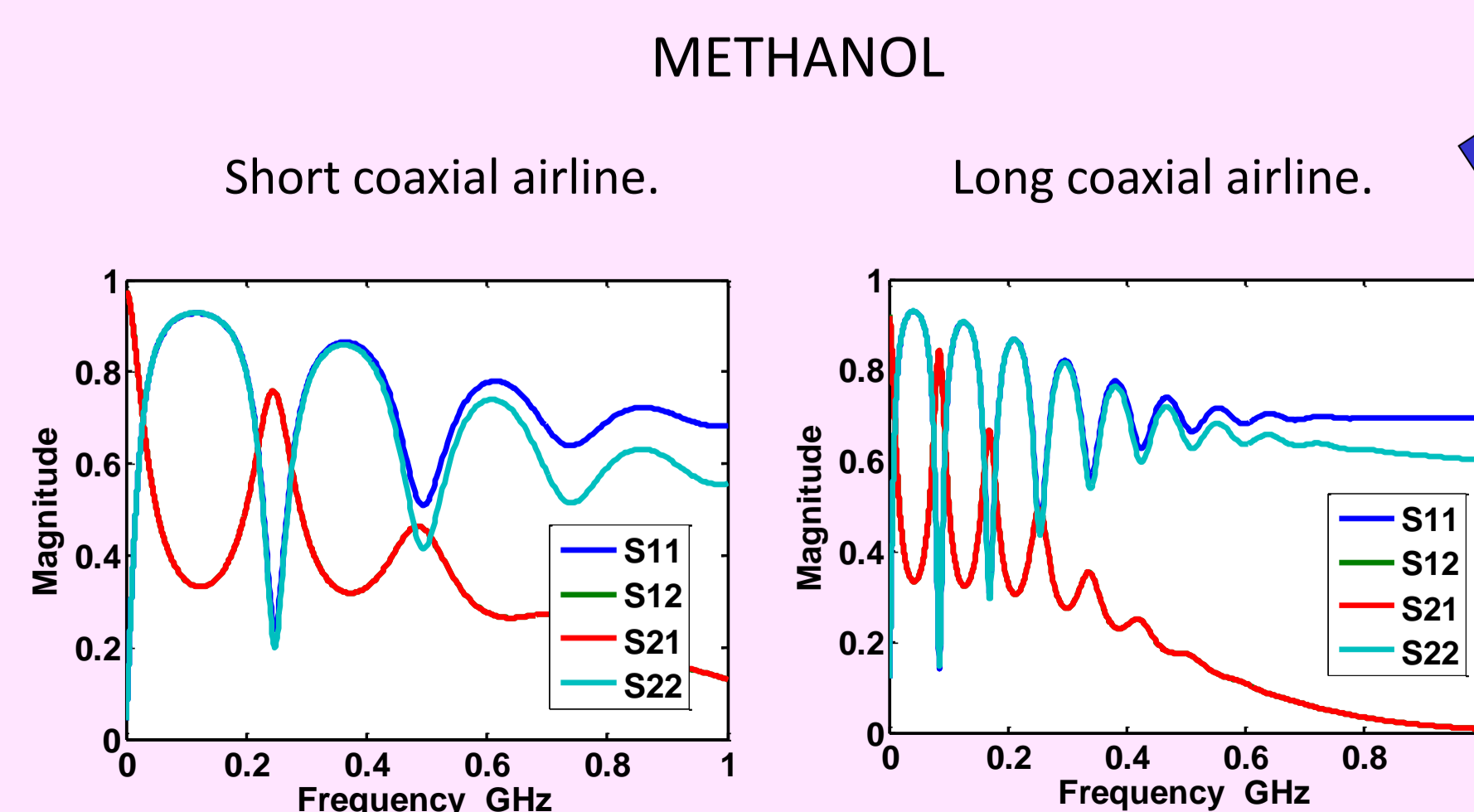
2 Transmission/Reflection: double-delay method [1]



Coaxial airlines [2]



Outer radius 3.5mm
Inner radius 1.5mm



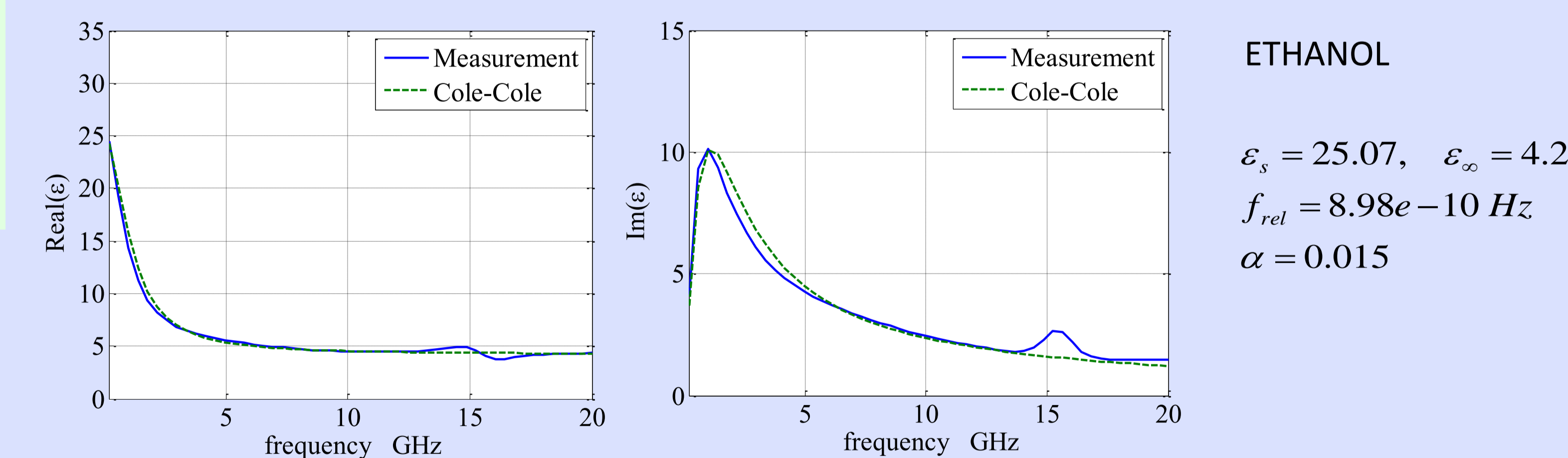
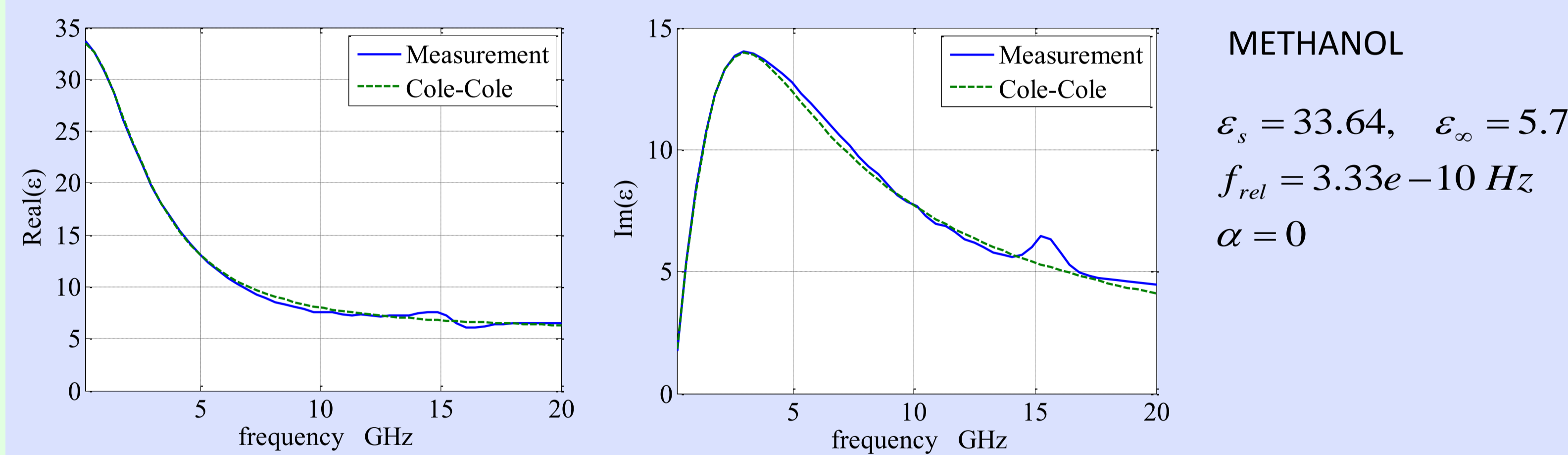
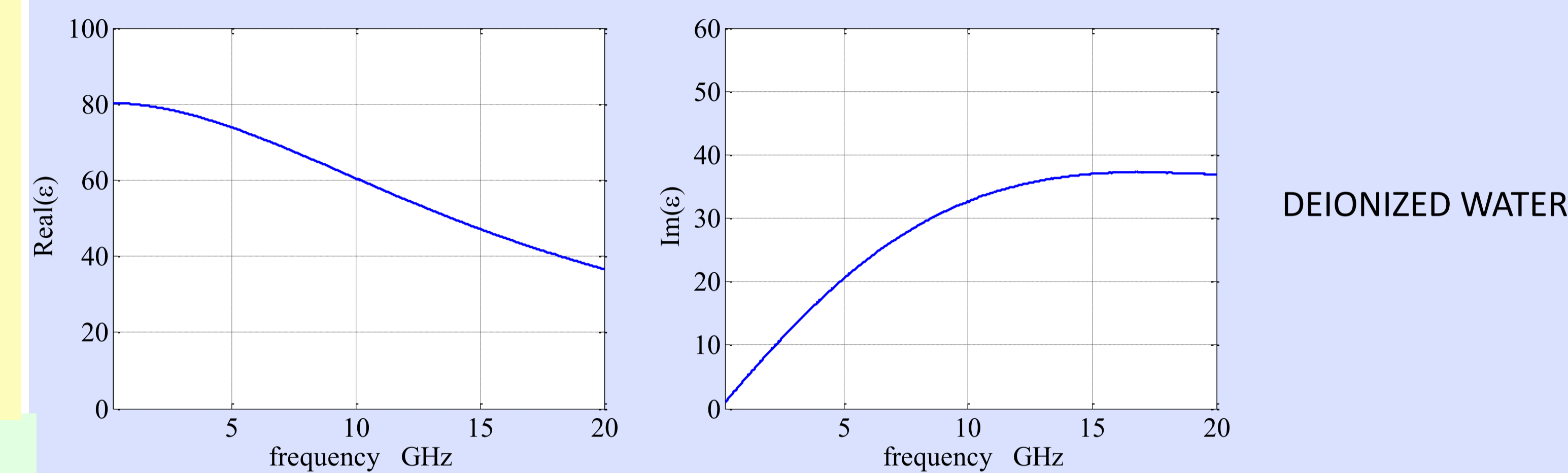
3 Open-ended coax probe (Agilent 85070D)

Frequency Range 200MHz to 20 GHz

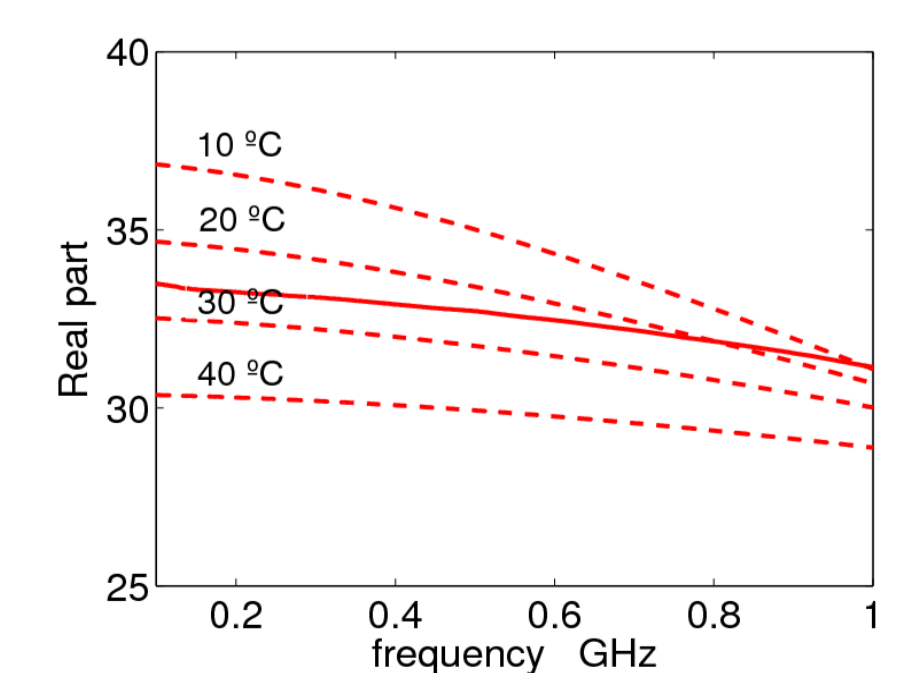
Accuracy: Permittivity $\pm 5\%$
 $\tan \delta = \pm 0.05$



3a Reference cases: deionized water, methanol and ethanol

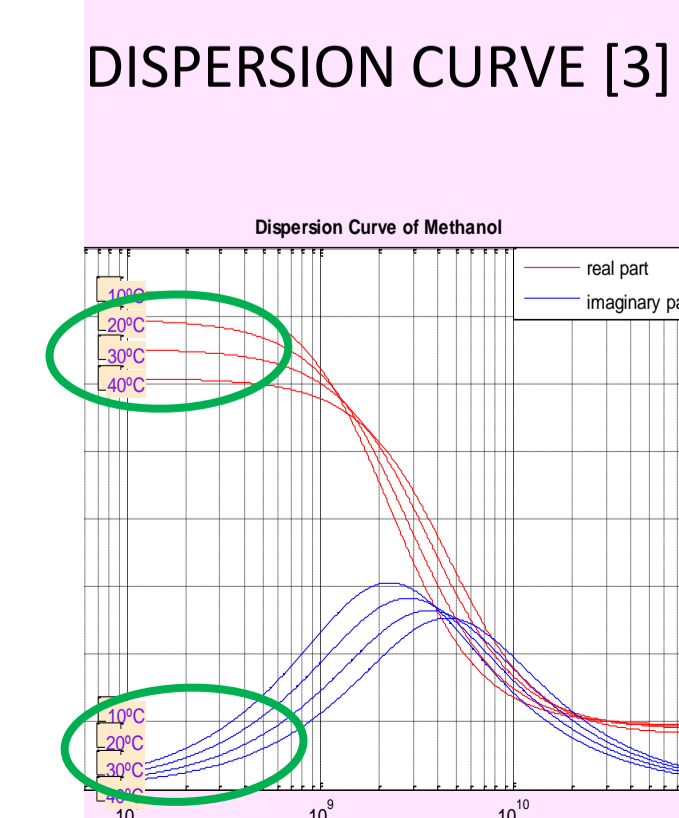


PERMITTIVITY – REAL PART

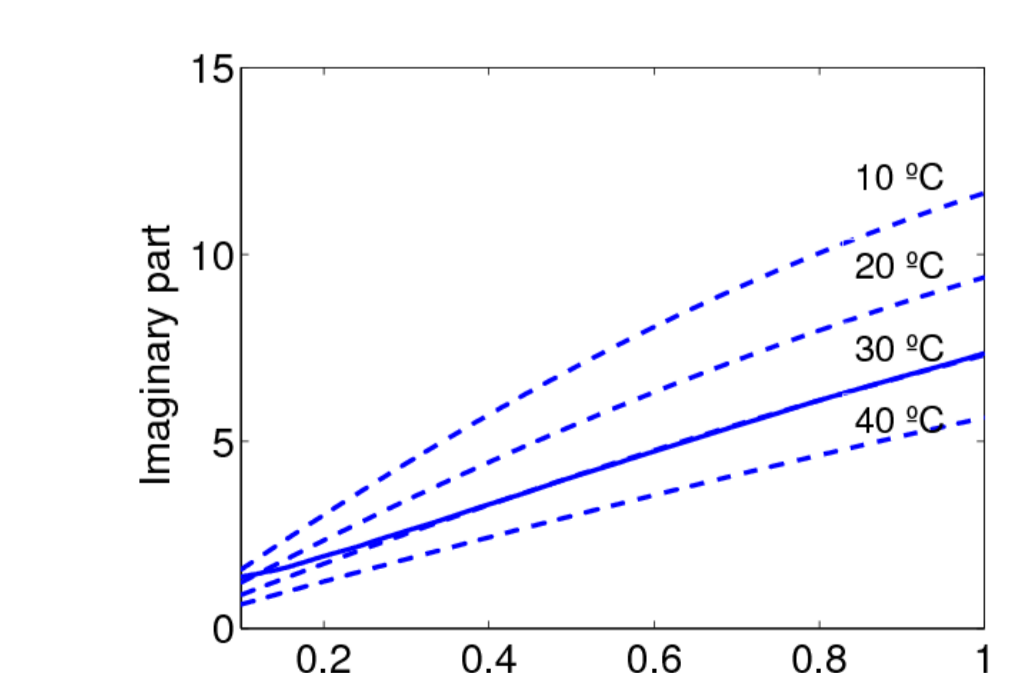


— Our measurements
- - - From [3]

METHANOL



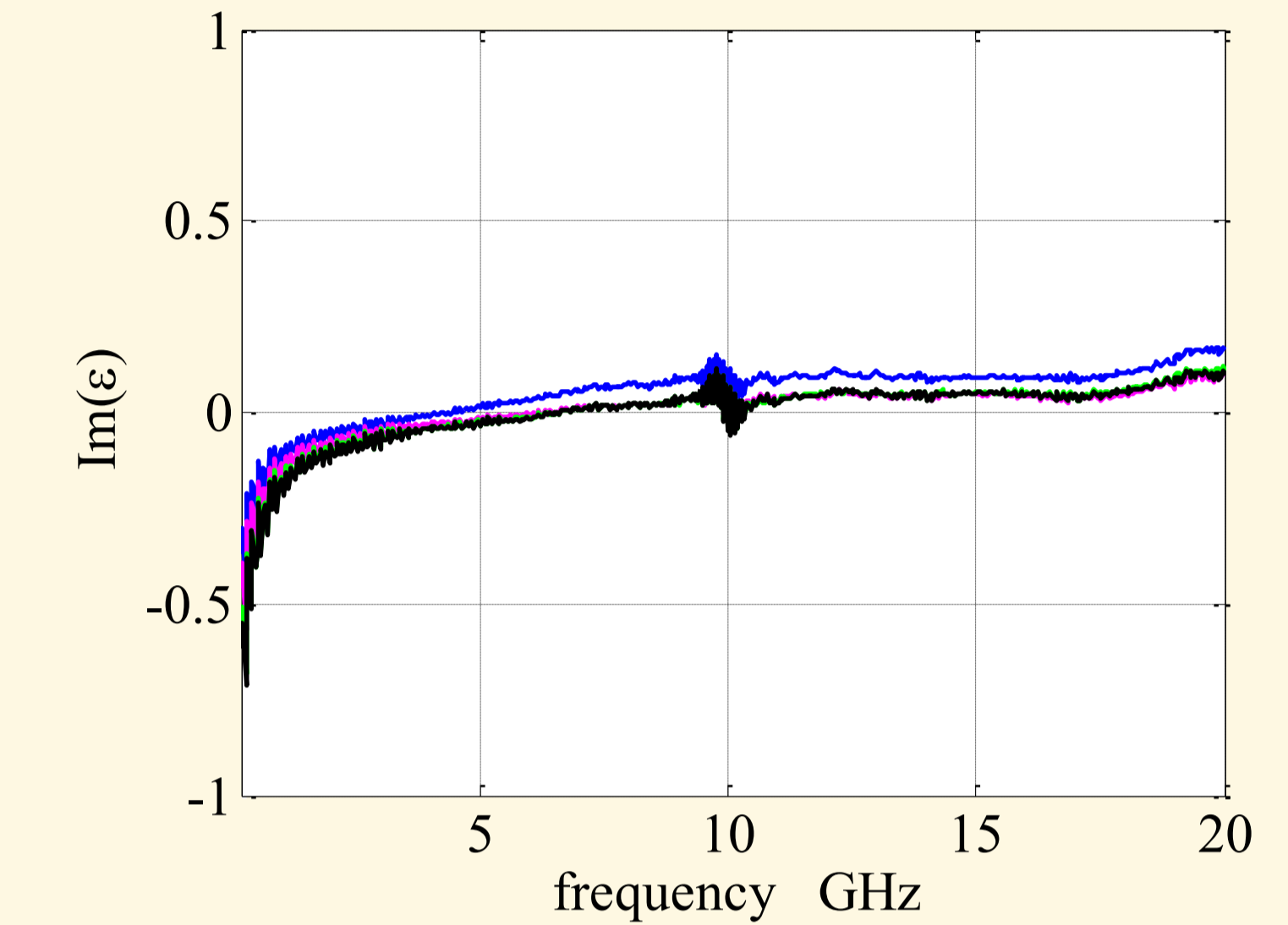
PERMITTIVITY – IMAGINARY PART



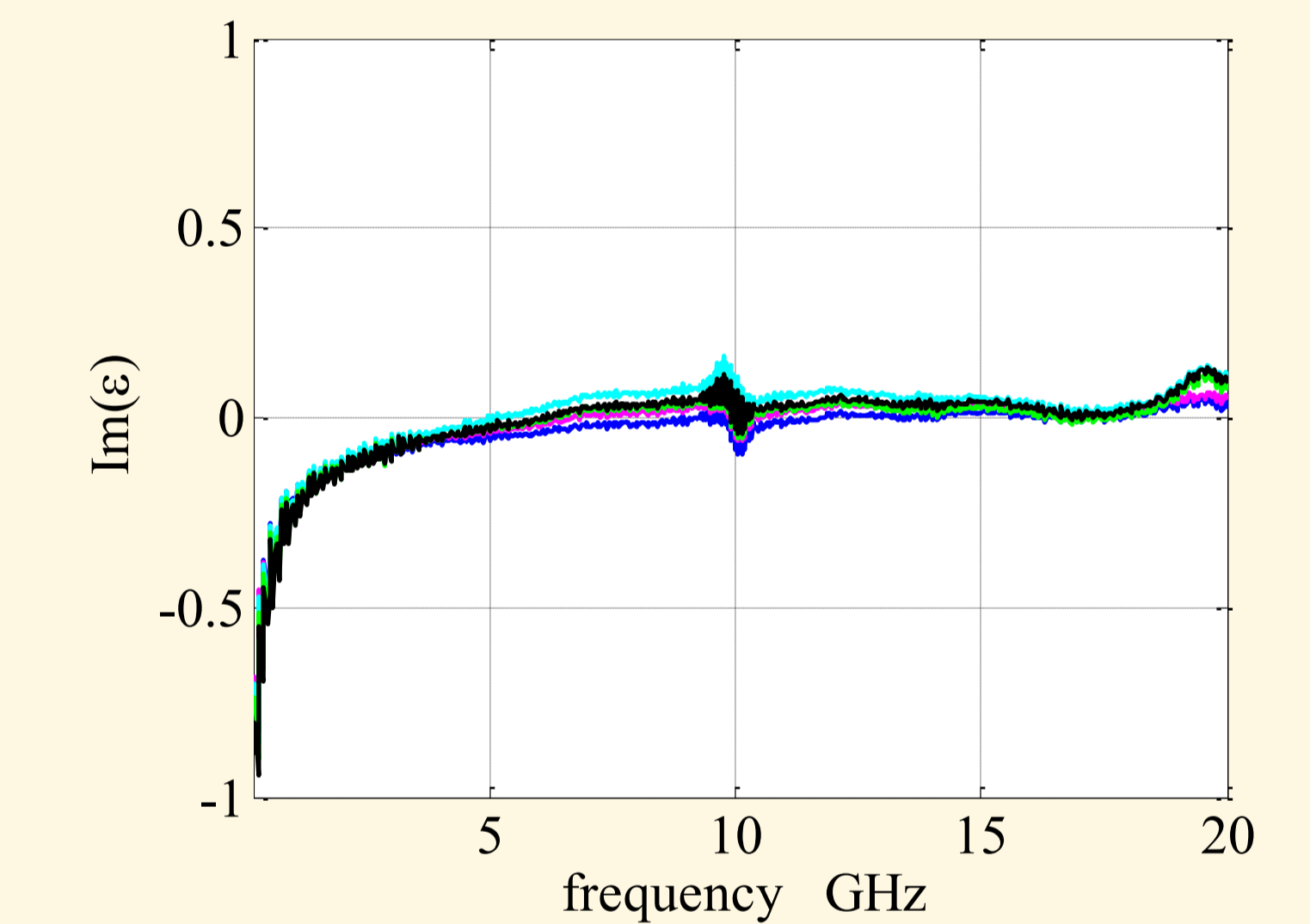
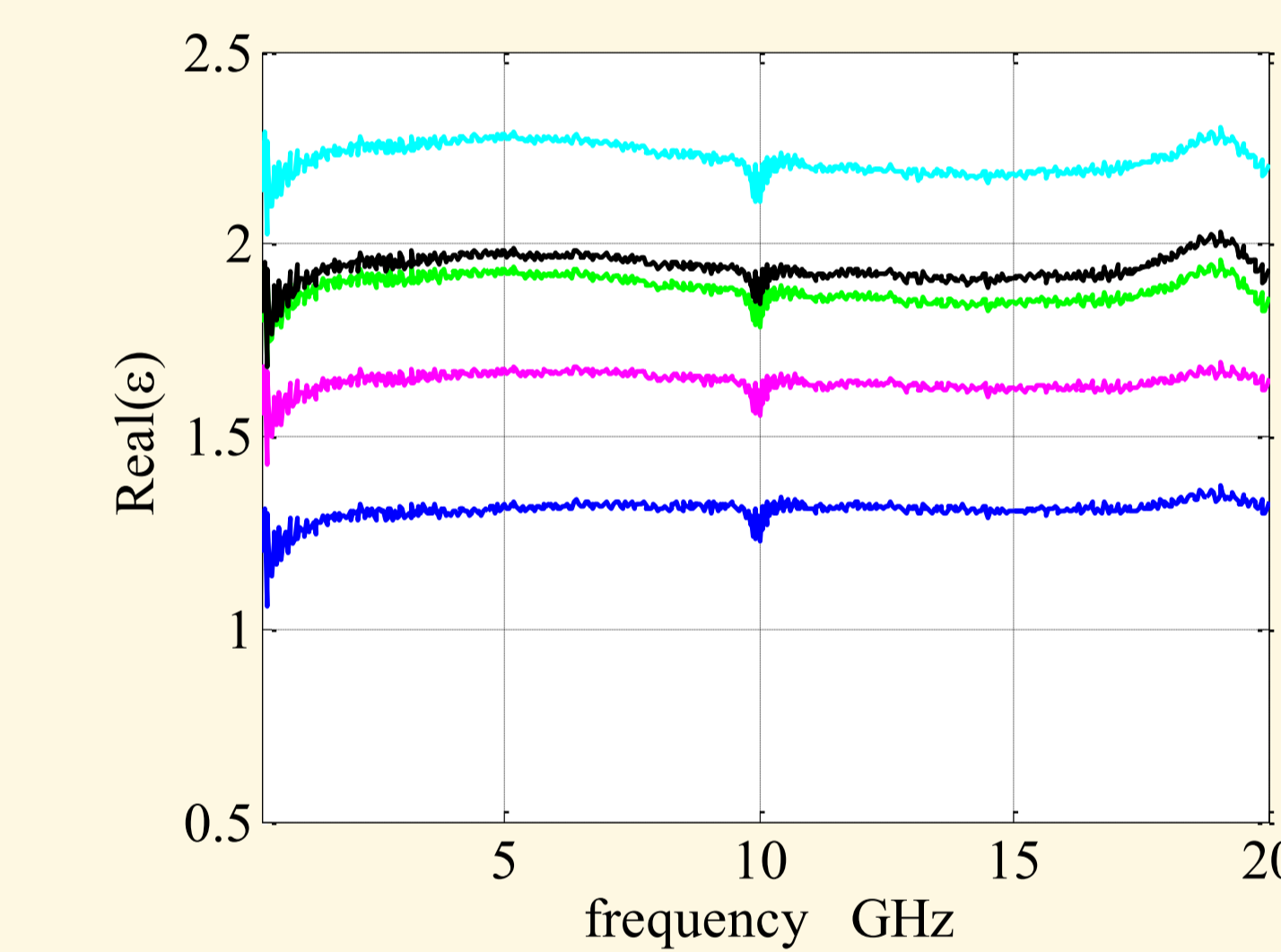
— Our measurements
- - - From [3]

3b Results: sand and clay

SAND



CLAY



CONCLUSIONS

Fringing Capacitive sensors can be used to measure the real and imaginary part of the permittivity of materials in the RF and microwave frequency bands. This type of sensor is particularly suited for liquid whereas for semisolid materials the contact surface and the granulosity of the sample are critical.

Bibliography

- [1] Rautio J.C., "A de-embedding algorithm for electromagnetics". *Int. Journal of Microwave and Millimeter-Wave Computer-Aided Engineering*, 1(3):282-2S7, 1991.
- [2] Savi P., Niyazov U., Maio I.A., "Complex Permittivity Determination from Measured Scattering Parameters of TEM Waveguides". *International Conference on Electromagnetics in Advanced Applications, Torino, September 12-17, 2011.*
- [3] Jordan B.P., Sheppard R.J. and Szwarnowski S., "The dielectric properties of formamide, ethanediol and methanol", *J. Phys. D: Appl. Phys.*, 11:695-701, 1978.