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Thin Photoresist Film Thickness Characterization Using 96-GHz Slotted Ring Resonator

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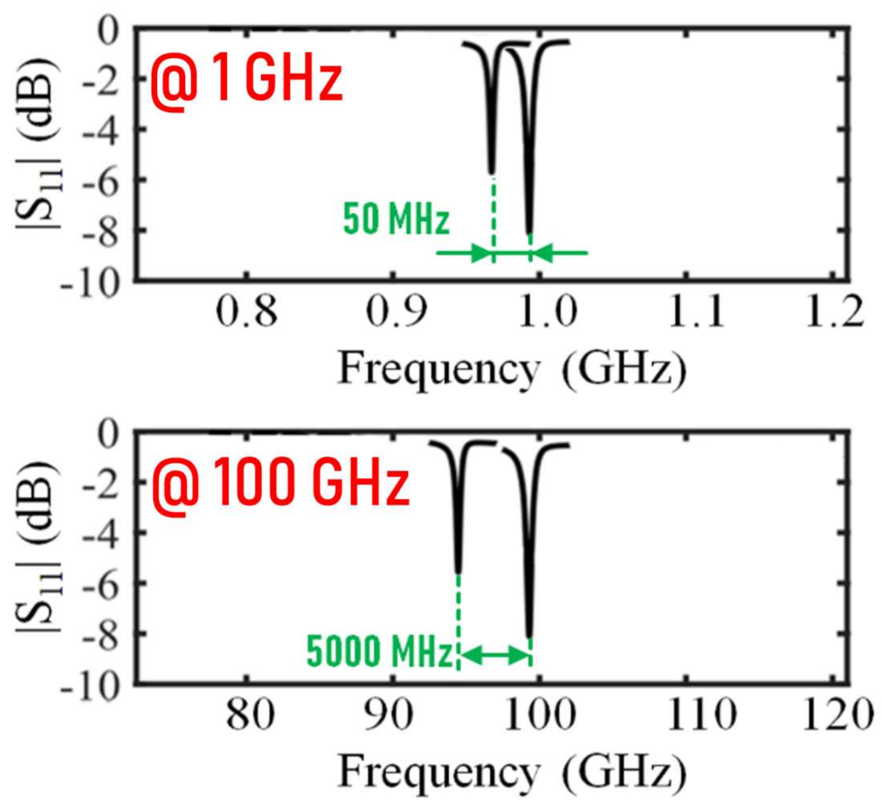
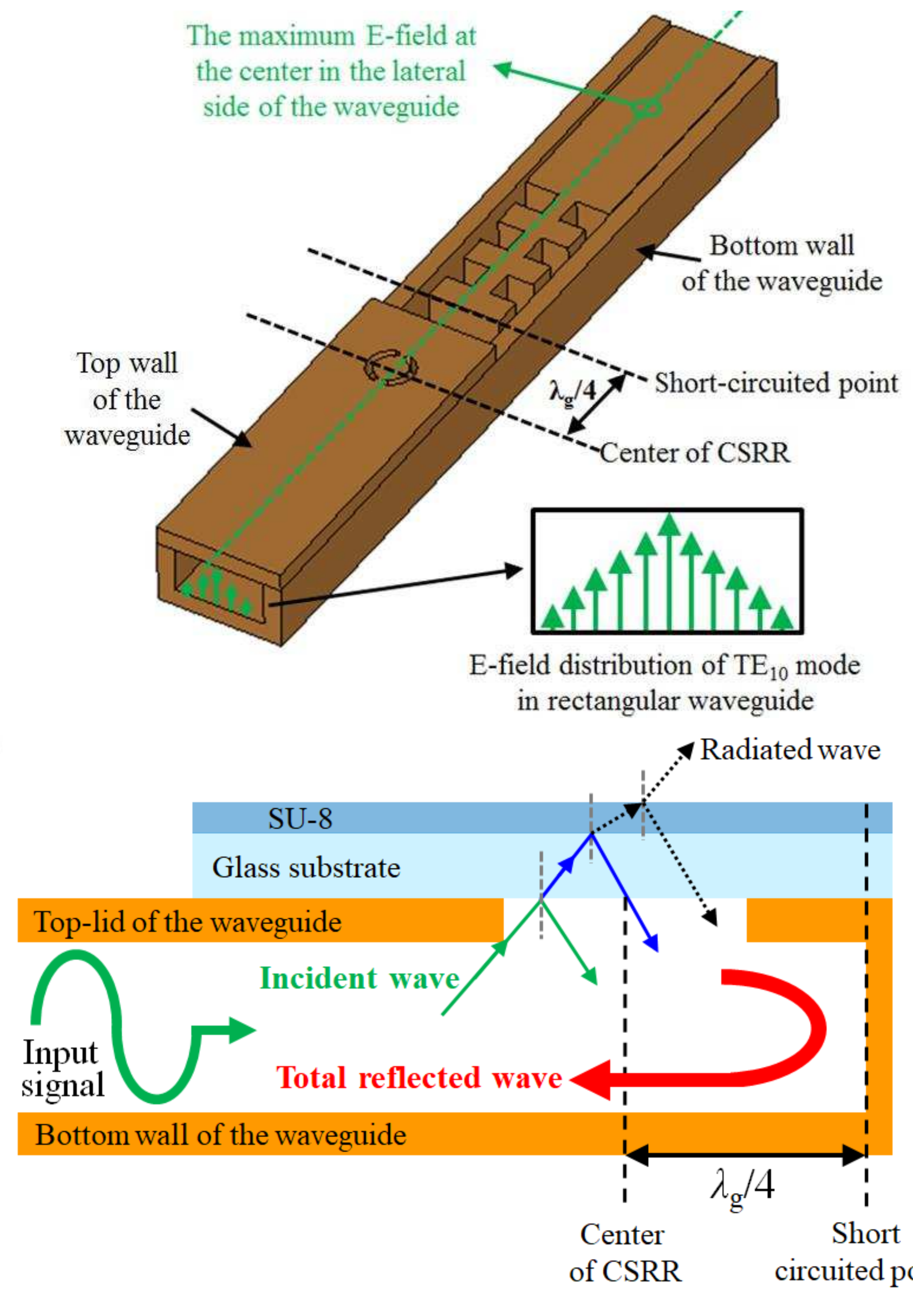
ABSTRACT

Non-destructive thickness measurement offers a valuable feature for thin polymer-based applications in both industrial and medical utilization. Herein, the author developed a novel, non-destructive, millimeter-wave WR-10 waveguide sensor for measuring a dielectric film layer on a transparent substrate. Complementary split-ring resonator (CSRR) was integrated on top of a customized WR-10 waveguide and operated at 96 GHz. The thickness of the SU-8 layers, ranging from 3-13 μm, coated on a glass substrate was then examined using the resonant frequency shift. The thickness values obtained from this novel sensor strongly resemble the values obtained from standard surface profiler measurement method, with less than 5 % difference. Thus, our novel design offers a comparable accuracy with a better cost effectiveness when compare with an existing commercial instrument.

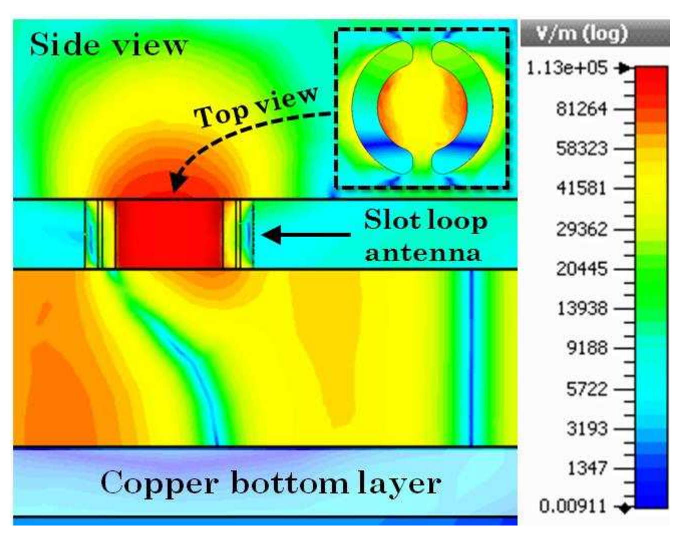
I. Thickness Characterization Working Principle

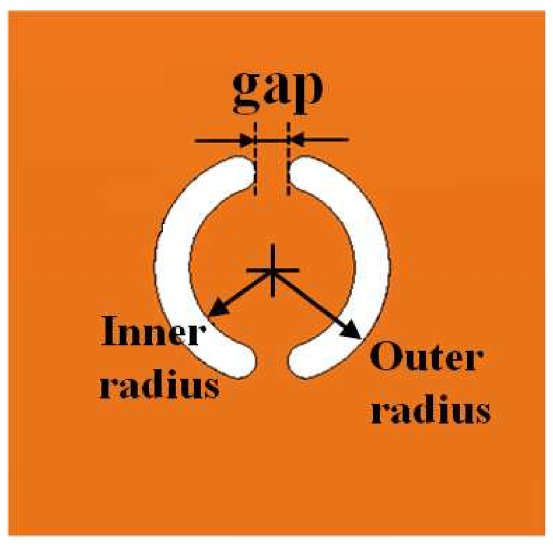


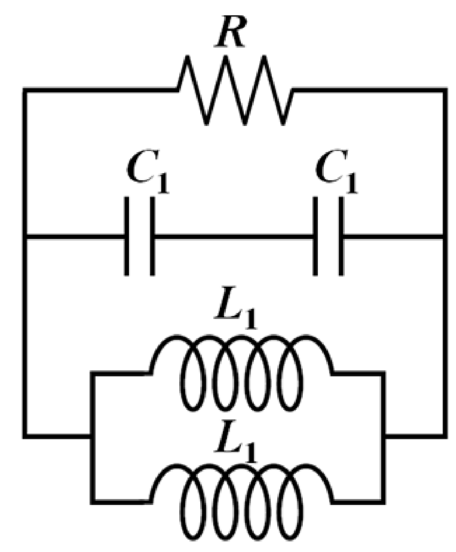
$$\Delta f = f_{r(glass)} - f_{r(SU\text{-}8)}$$

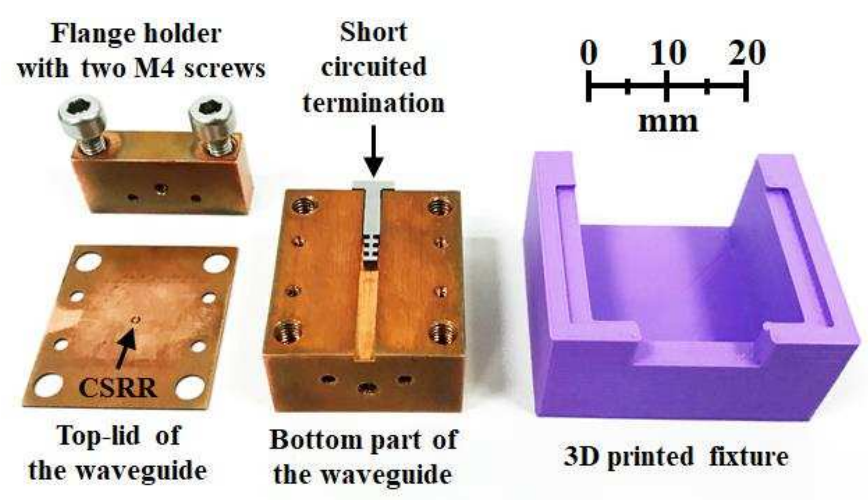


II. Sensor Design and Fabrication

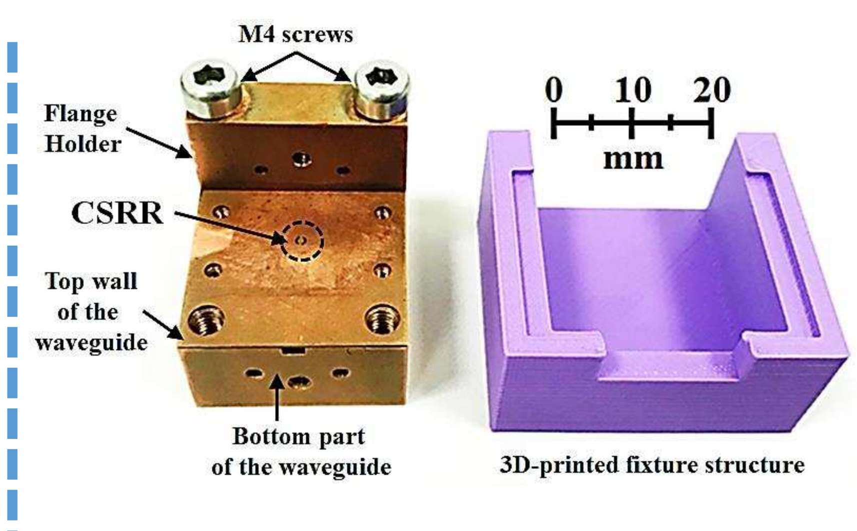






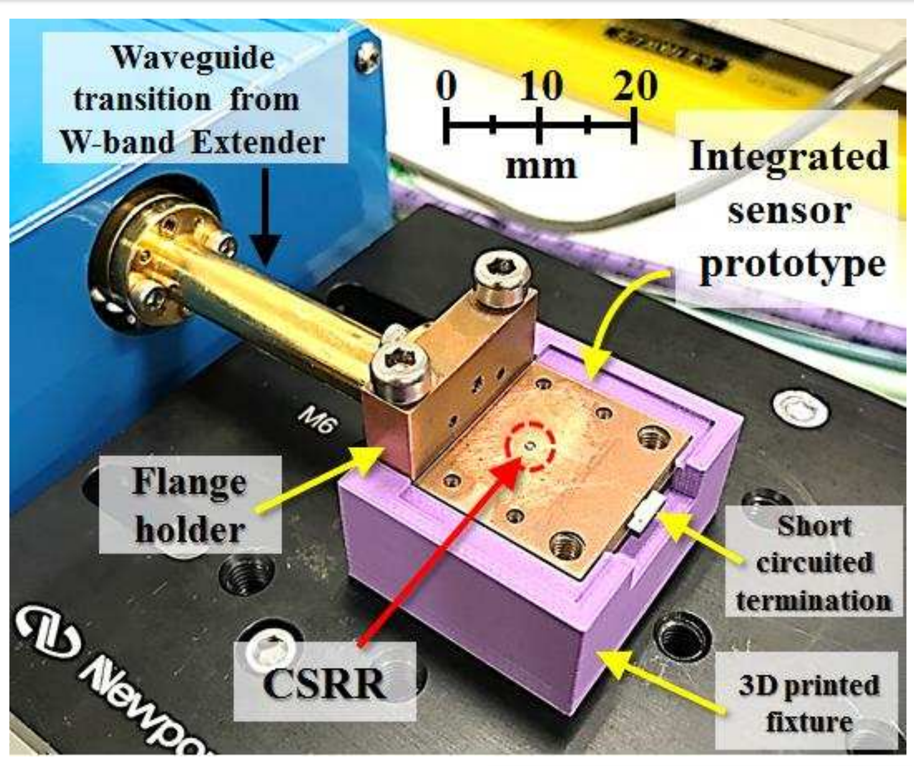


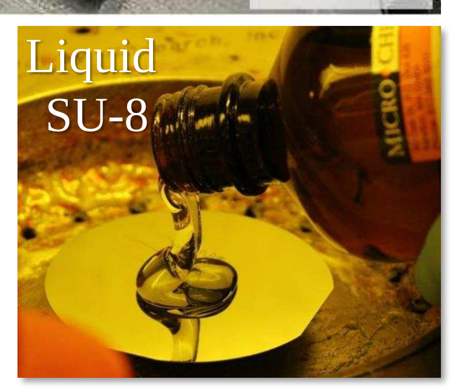
Before integration



After integration

III. Measurement Setup & Measurement Results





Glass Thickness Characterization

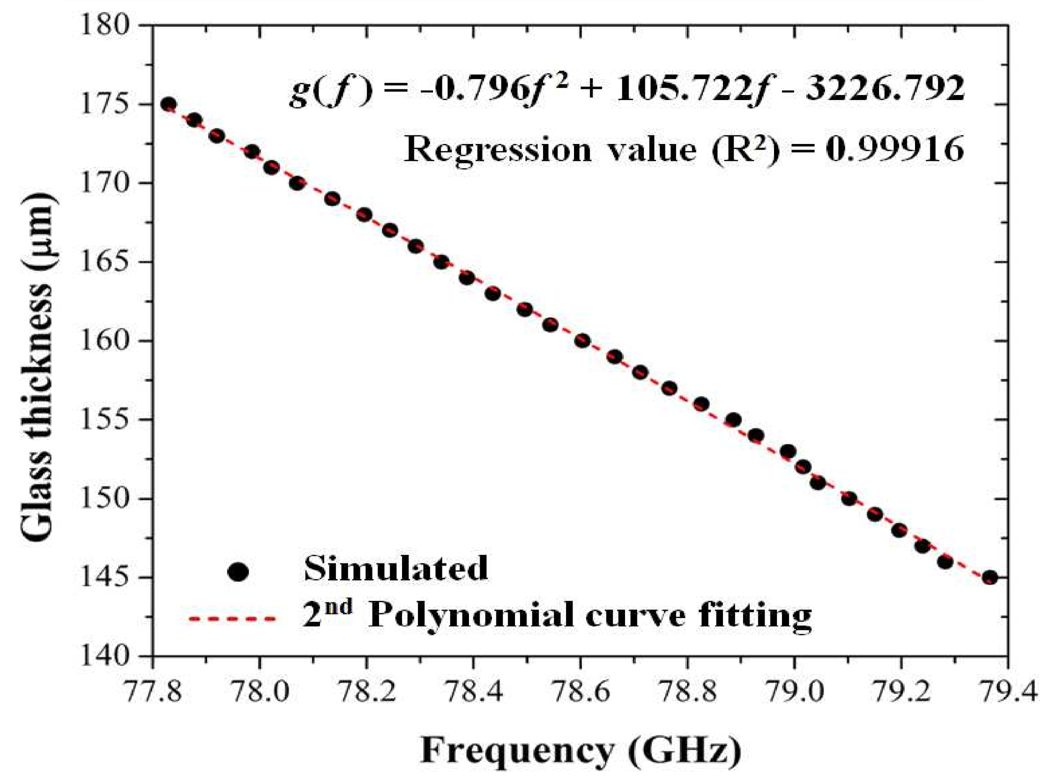


Table. I Extracted results of five glass substrate thicknesses

No.	Measured resonance frequency (GHz)	Extracted glass thickness from (1) (μm)	Measured glass thickness from Alpha-step (μm)	% Difference
1	78.955	153.0715	152.75	0.2105
2	78.815	155.8708	155.75	0.0776
3	78.670	158.7176	158.20	0.3272
4	78.570	160.6946	160.50	0.1212
5	78.500	162.0552	161.75	0.1887

SU-8 Thickness Characterization

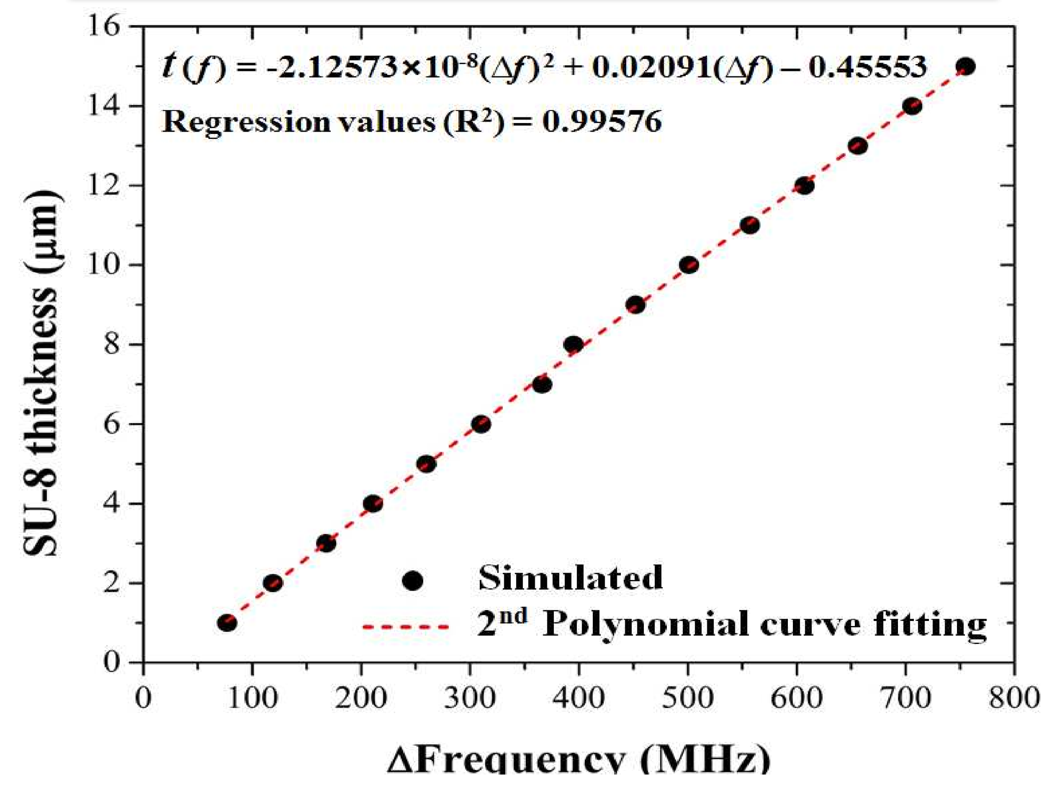


Table. II Extracted results of three SU-8 layer thicknesses

No.	Measured resonance frequency change, Δf_r (MHz)	Extracted SU-8 layer thickness from (2) (μm)	Measured glass thickness from Alpha-step (μm)	% Difference
1	140	2.4715	2.50	1.14
2	210	3.9346	3.75	4.92
3	315	6.1290	6.33	3.18
4	525	10.5164	10.20	3.10
5	665	13.4402	13.56	0.88

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