Ion-beam sputtering deposition of DLC thin films

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Ion-beam sputtering Setup

- Room Temperature (23°C)
- Vacuum 10^{-5} mbar
- Pre-treatment with $O\bullet$ / $Ar\bullet$ radicals
- Ion Beam Source ($\sim$ 1200 eV)
- Assistant Source ($\sim$ 100 eV)
- Graphite Target: $\varnothing$10 cm
- Substrate: $6 \times 6\,\mathrm{cm}^2$
- Quartz balance $\rightarrow$ Film thickness
- Deposition speed $\sim$ 100 nm / hour

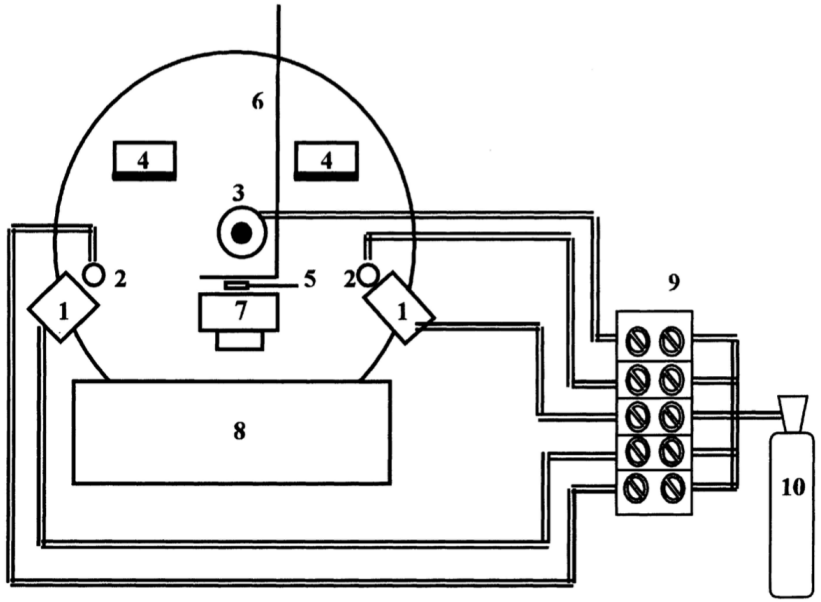

FIGURE 1 Schematic representation of the dual ion-beam sputtering deposition system used: (1) sputtering ion-beam sources, (2) plasma bridge neutralizers, (3) assistance ion-beam source, (4) targets, (5) quartz microbalance, (6) shutter, (7) substrate holder, (8) turbomolecular pump, (9) flow control unit, (10) argon supply

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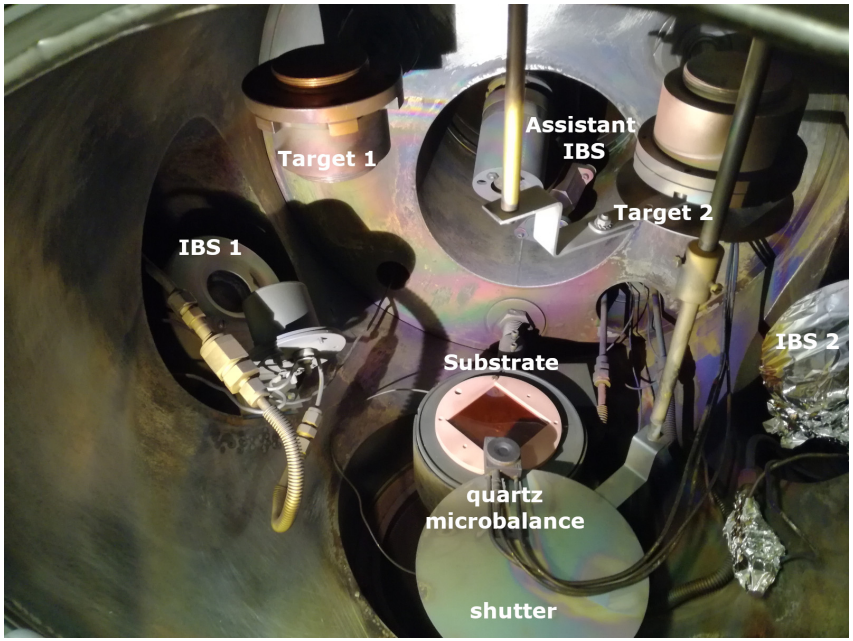
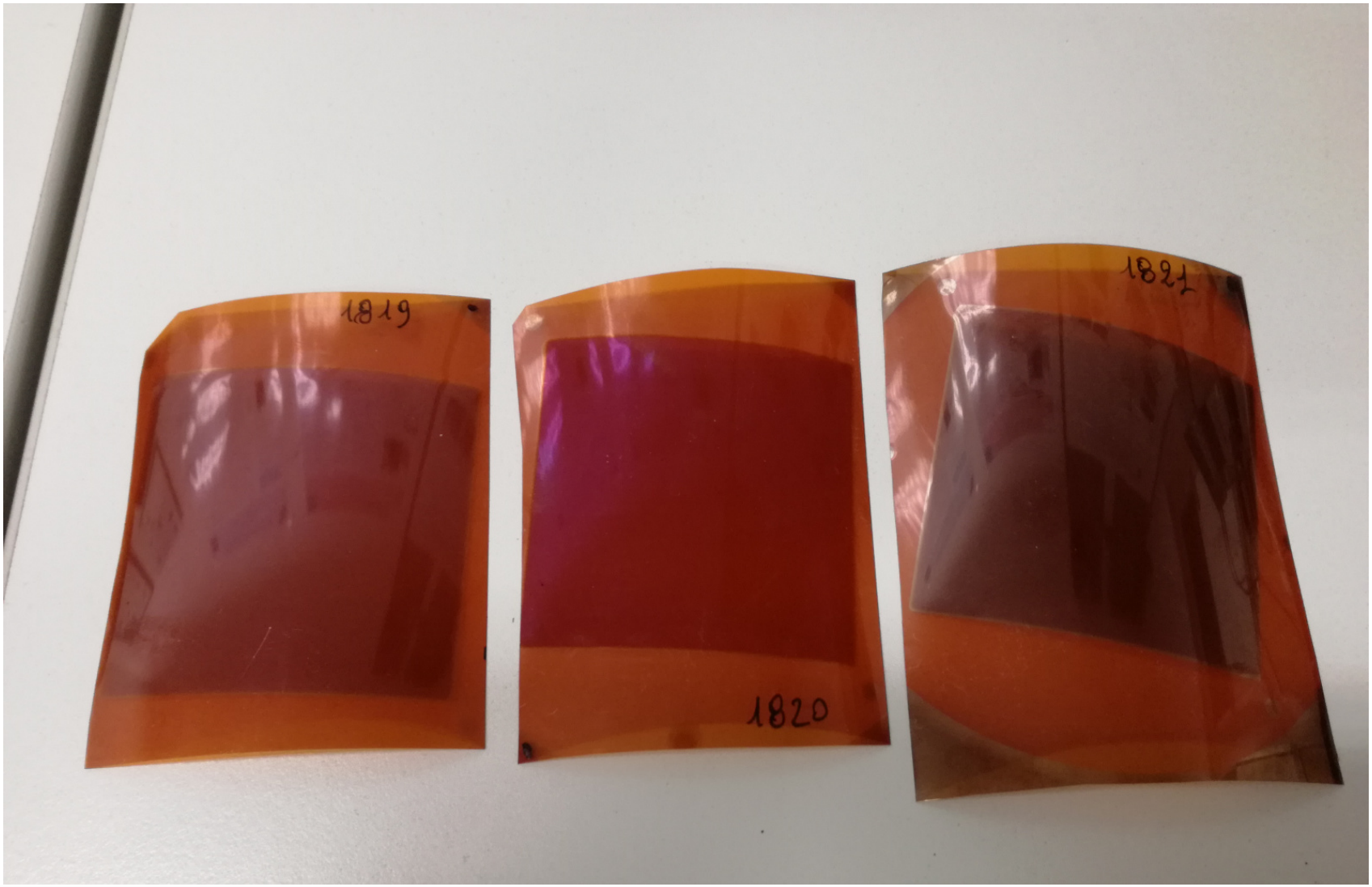


DLC Deposition Parameters

Number	1	2	3
Sample	1819	1820	1821
Pre-Treatment	O_2	O_2	Ar_2
	10 cc/min	10 cc/min	10 cc/min
	900 s	300 s	300 s
	0.5 A	0.7 A	2.6 A
	100 eV	100 eV	100 eV
Main Ion Beam	Ar	Ar	Xe
	2.5 cc/min	2.5 cc/min	2.5 cc/min
	1200 eV	1200 eV	1200 eV
	80 mA	60 mA	60 mA
Aux Ion Beam	Ar	Ar	Ar N_2
	7 cc/min	7 cc/min	5 cc/min 2 cc/min
	60 eV	100 eV	50 eV
	0.5 A	1.17 A	0.22 A
	all time	first 5 nm	all time
Doping	-	-	N_2
			2 cc/min
Thickness	100 nm	100 nm	100 nm
Deposition Time	3600 s	2700 s	4500 s
	60 min	45 min	75 min

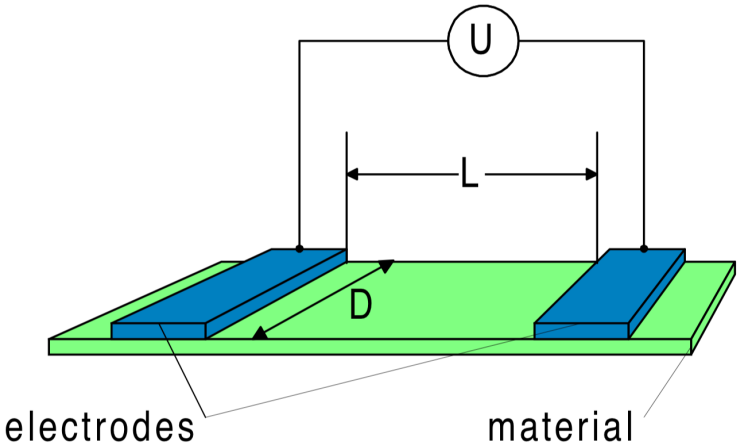
The Samples

1819 – 1820 – 1821



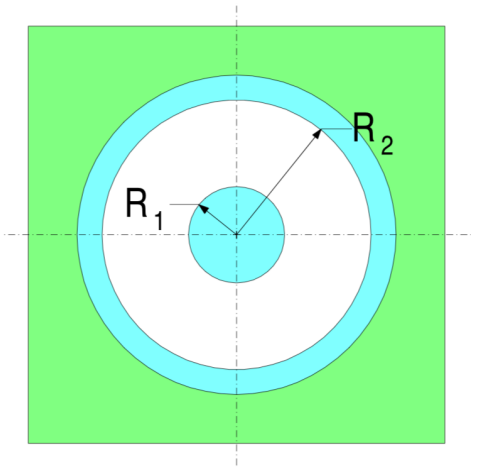
Surface Resistivity Measurements

linear electrodes



$$\rho_S = \frac{D}{L}\frac{U}{I_S} = \frac{D}{L}R_S$$

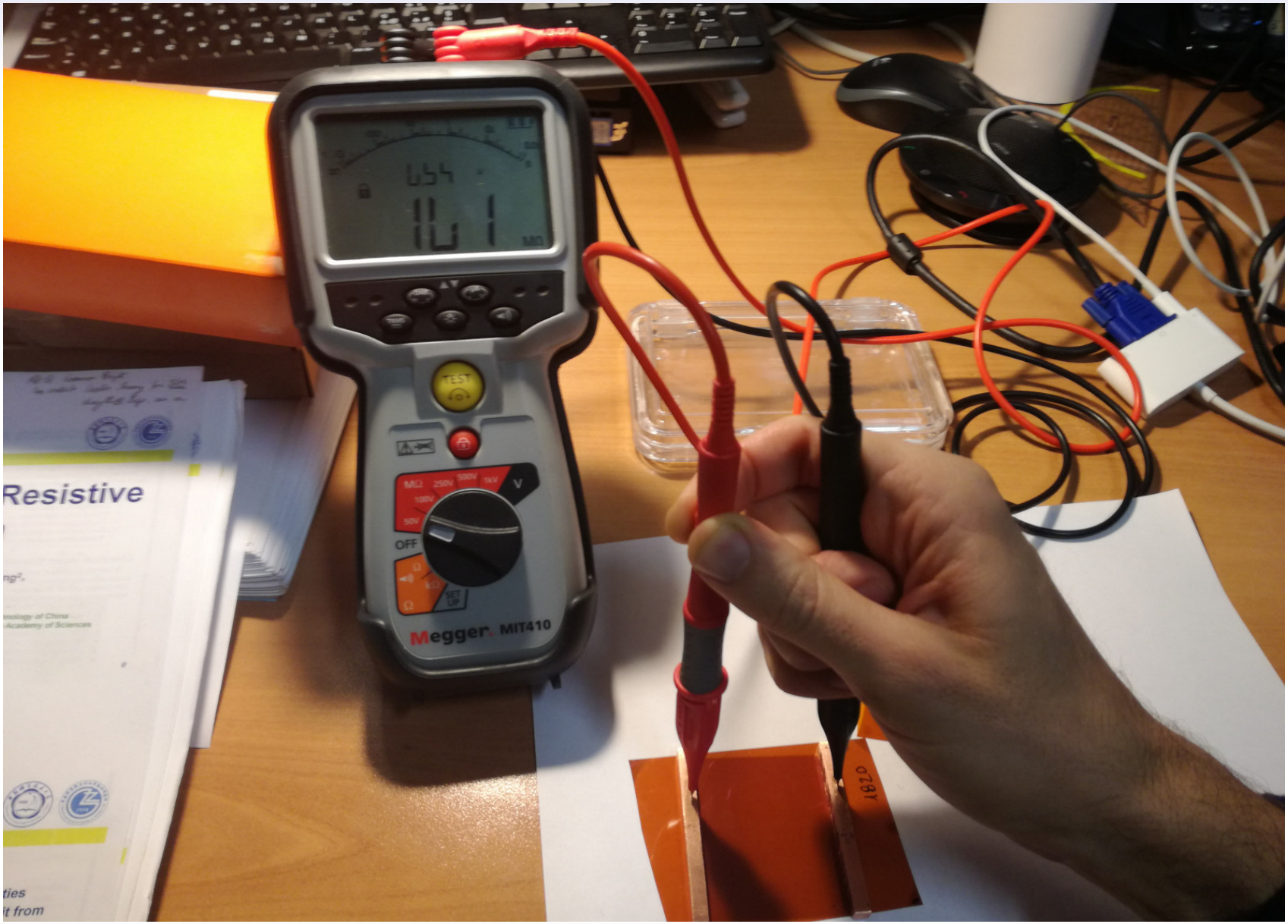
concentric electrodes



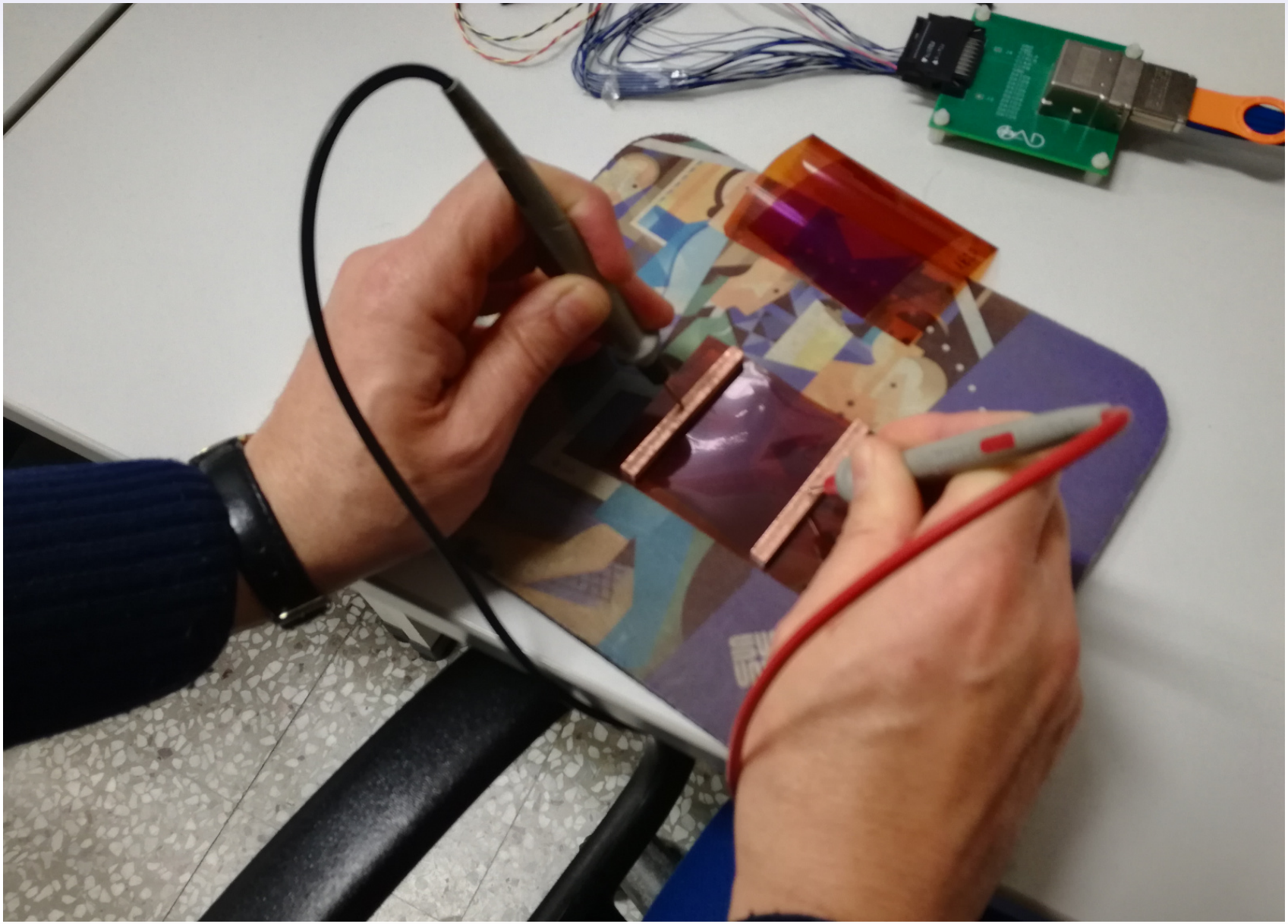
$$\rho_S = R_S \frac{2\pi}{\ln \frac{R_2}{R_1}}$$

http://www.trekinc.com/pdf/1005_Resistivity_Resistance.pdf

Surface Resistivity Measurements

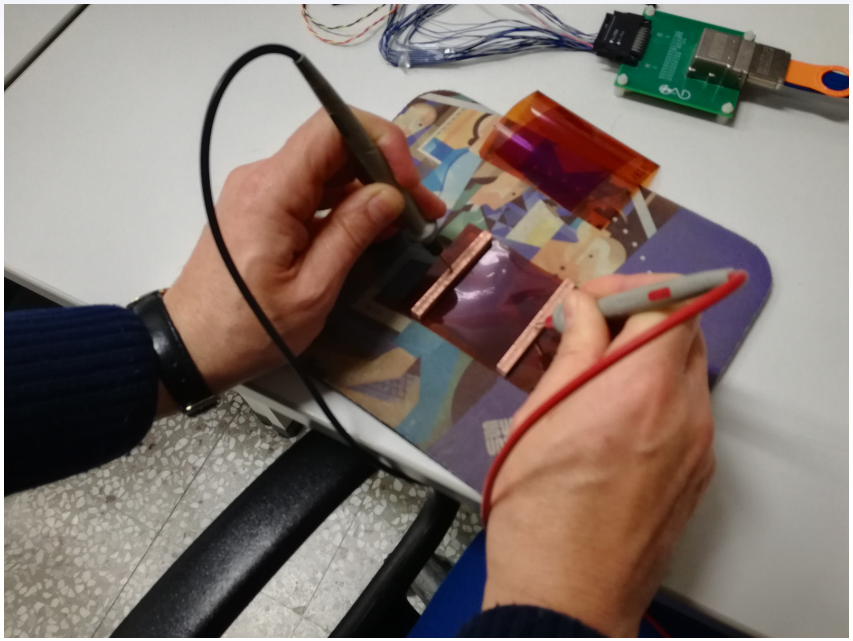


Surface Resistivity Measurements



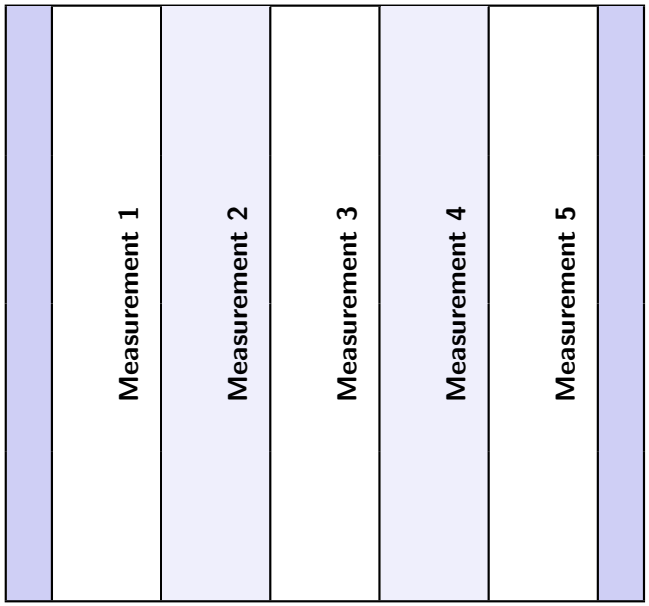
Surface Resistivity Measurements

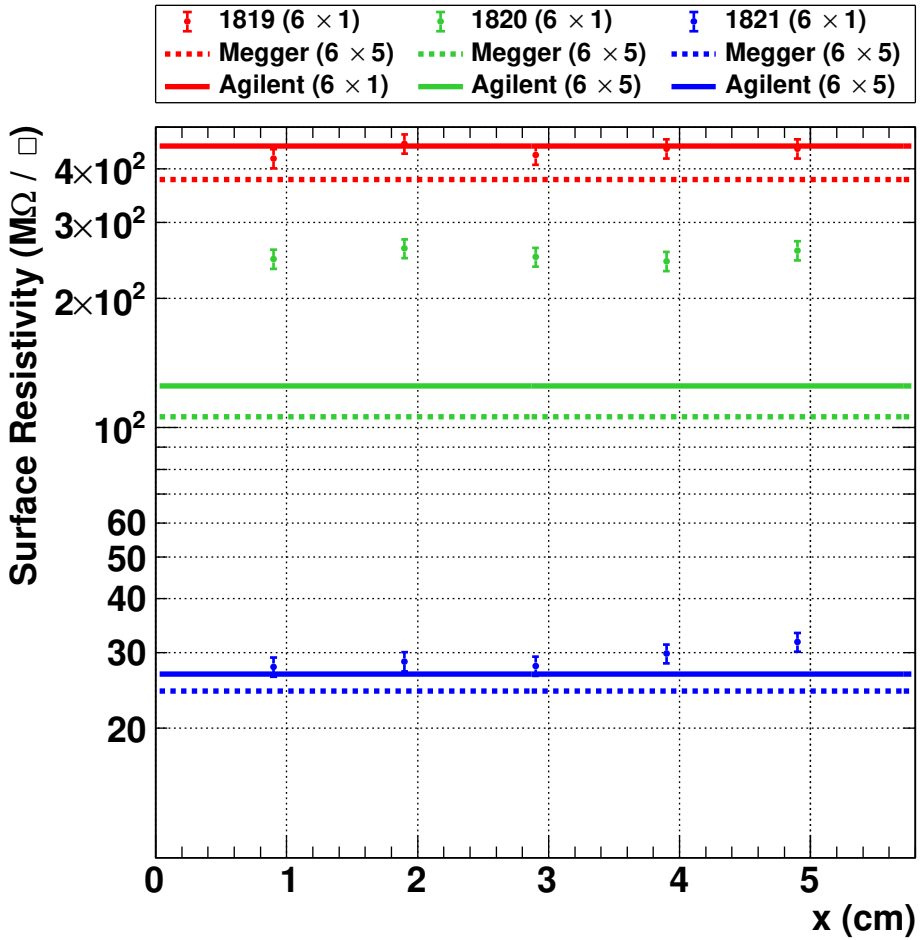
- Sample size: $6 \times 6\,\mathrm{cm}^2$
- Cu-bars: $6 \times 0.5 \times 0.5\,\mathrm{cm}^3$
- $D = 6\,\mathrm{cm}$; $L = 5\,\mathrm{cm}$
- Sample on soft tissue (mouse pad) to increase contact under pressure
- Orientations: Horizontal & Vertical
- **Insulation Tester: Megger MIT 410**
- **Multimeter: Agilent 34401A**



			Megger (H)			Megger (V)			Agilent (H)		Agilent (V)	
N°	Sample	U [V]	I_S [μA]	R_S [MΩ]	ρ_S [M$\Omega/\square$]	I_S [μA]	R_S [MΩ]	ρ_S [M$\Omega/\square$]	R_S [MΩ]	ρ_S [M$\Omega/\square$]	R_S [MΩ]	ρ_S [M$\Omega/\square$]
1	1819	58 V	0.18	315	378	0.17	333	404	$75.3^{(*)}$	452	$82.0^{(*)}$	492
2	1820	58 V	0.66	88	106	0.60	95	114	104	125	104	125
3	1821	58 V	2.87	20	24	2.53	23	27	22.25	26.7	27.5	33.0

Resistivity Uniformity Measurements





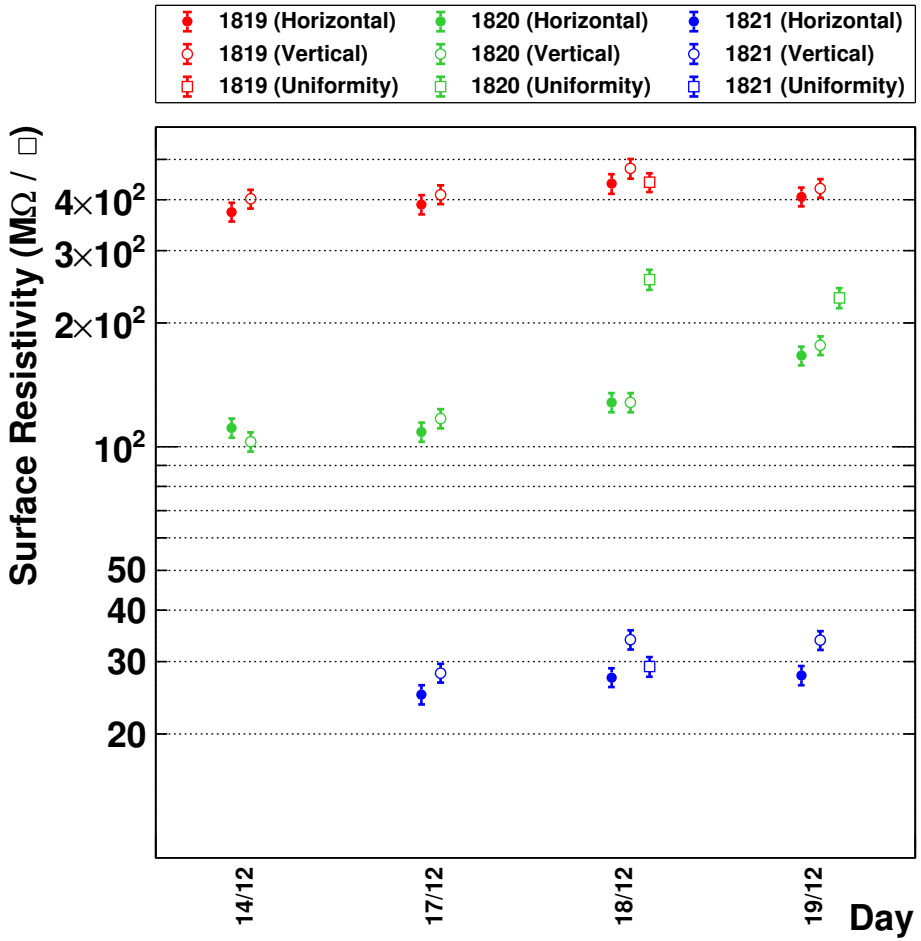
1819 Uniformity: $\sigma/\mu = 2.7\,\%$

1820 Uniformity: $\sigma/\mu = 2.7\,\%$

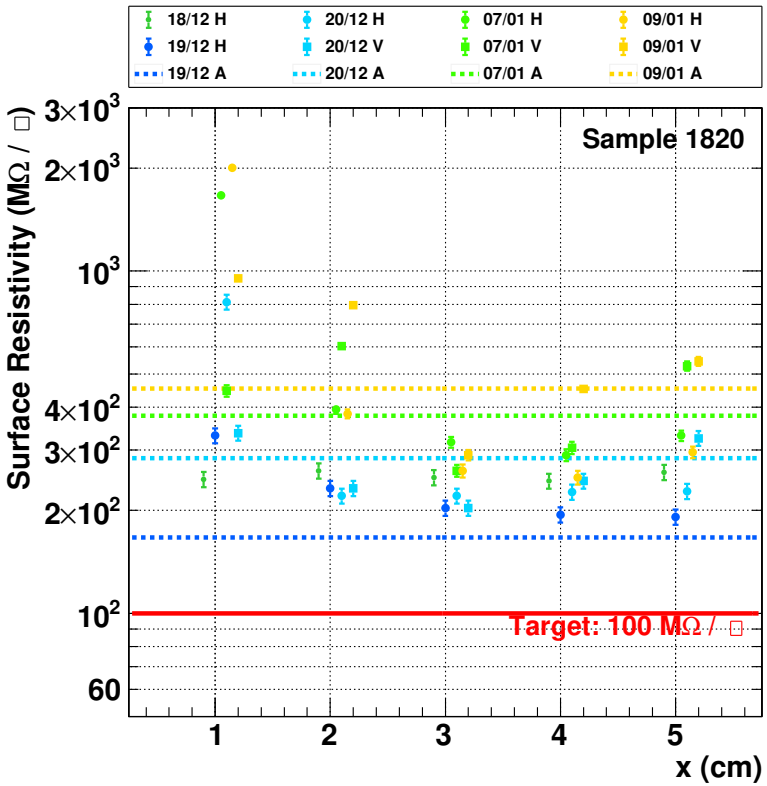
1821 Uniformity: $\sigma/\mu = 5.0\,\%$

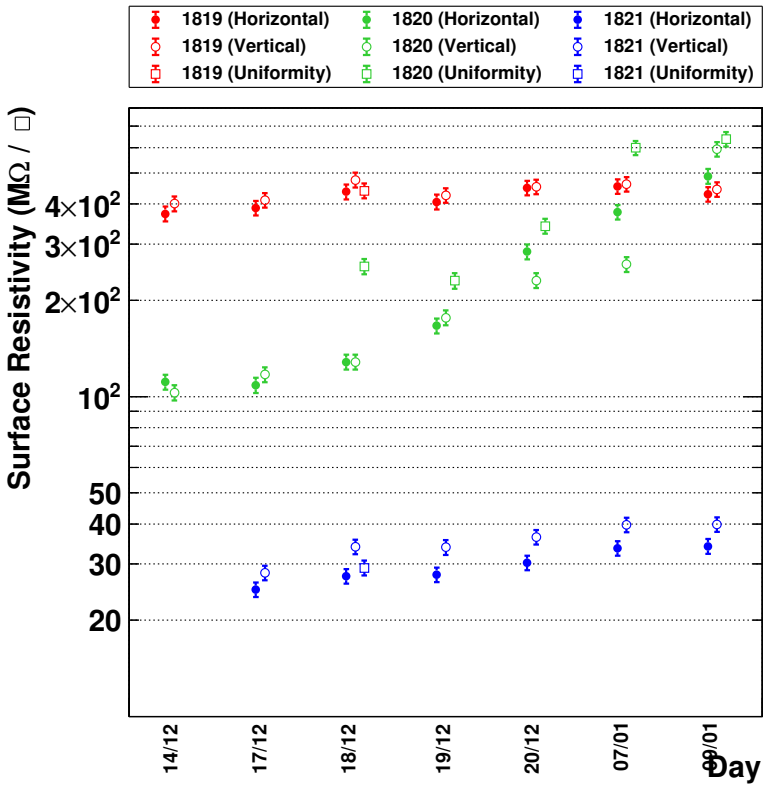
Surface Resistivity Time Evolution

- Measured Surface Resistivity in different days
- Measured in Horizontal position, Vertical position and made average of Uniformity Measurement
- Stable for Sample 1819, 1821, upgoing for 1820
- High values obtained for Uniformity Measurement not reproduced with single Measurements for 1820
- Surface Resistivity going up for 1820, I might have damaged 1820 on 19/12



Surface Resistivity Time Evolution





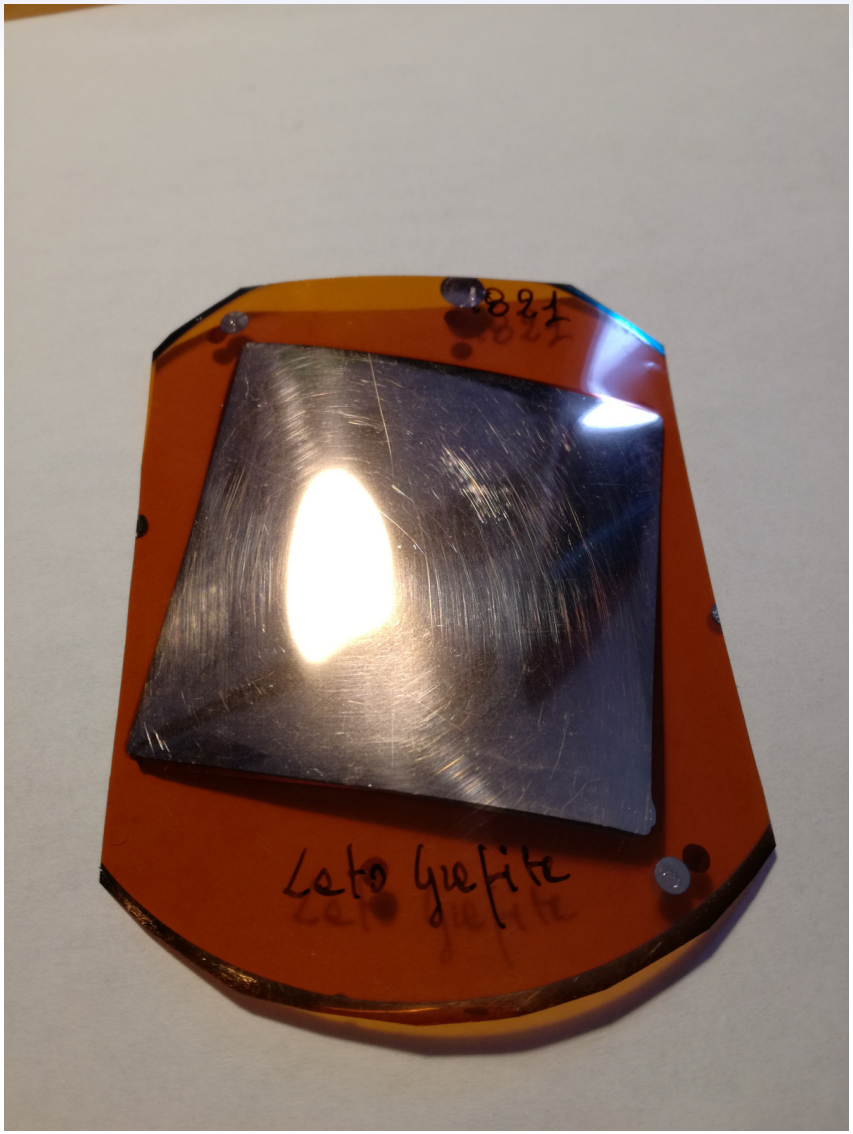
Observations

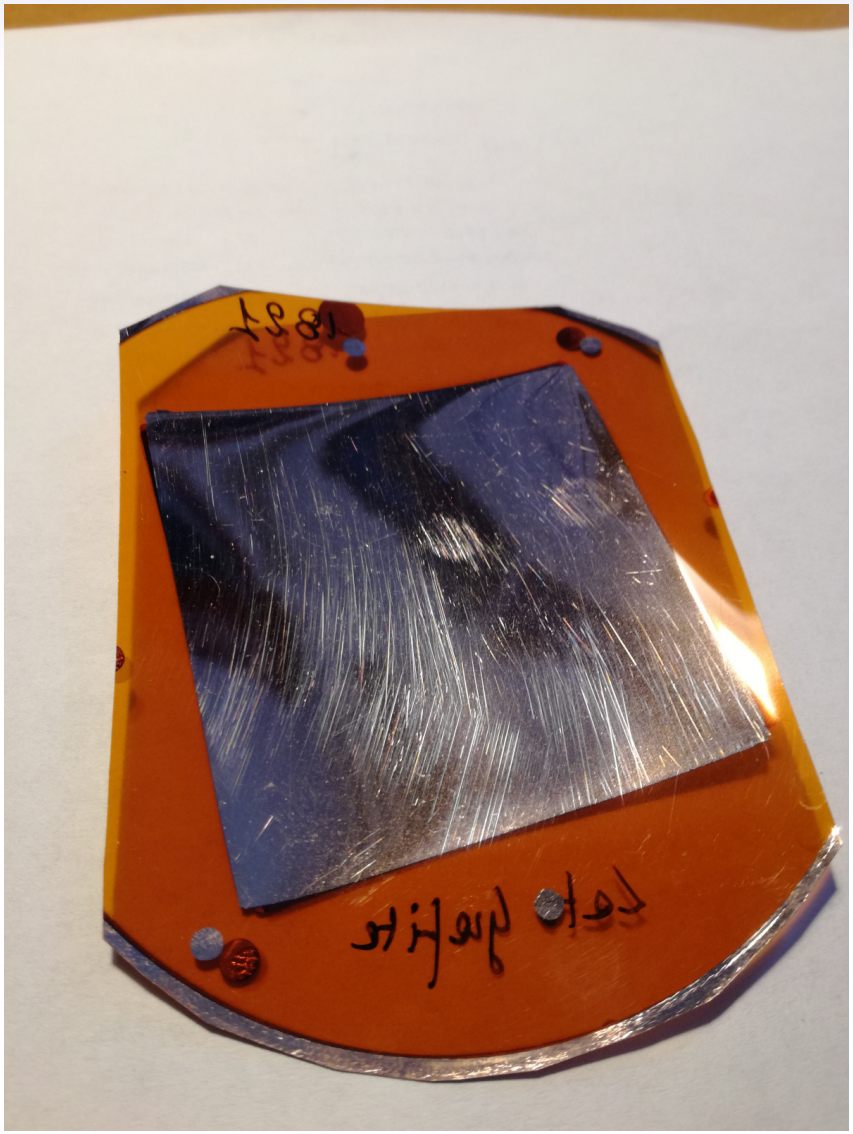
- Resistivity Measurement depends on pressure extracted on Cu bars, which influences contact Cu bar – Substrate
- Good agreement between *Overall* measurement and *Small* measurements for samples 1819 & 1821, factor 2 difference for sample 1820
- Uncertainty of 5 % on Surface Resistivity, dominated by uncert on position / lengths (assuming 0.5 mm uncertainty on L, D)
- Promising Uniformity of 3–5 %
- Derivation of formulae on slide 5 indicate that error is larger for concentric electrode setup?

Future work

- Want to make new Mask to allow $10 \times 10\,\mathrm{cm}^2$ samples (see fig next slide)
- Want to estimate error made by using only Multimeter w.r.t. Multimeter + Cu bars to estimate surface resistivity
- Need a mechanical tool to exercise uniform pressure on bars + keep the distance fixed at high precision
- Deposit / Sputter conductive Strips on substrate before sputtering DLC to allow for good electrical contact. Need to make Mask.

Deposition of 1 μm Cu on top of DLC





Substrate Holder