

Ultra High Density Capacitor for Power Management Applications

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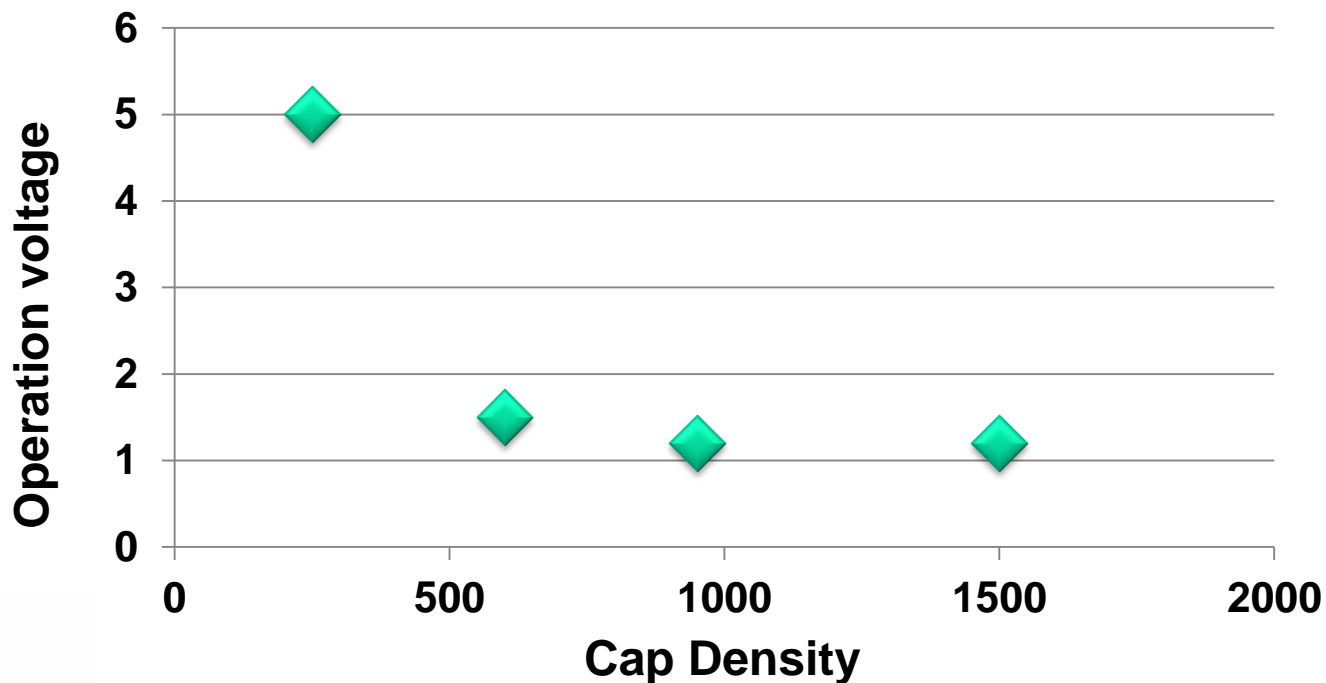
Taiwan Semiconductor Manufacturing Company,
Hsin-Chu, Taiwan.

Outline

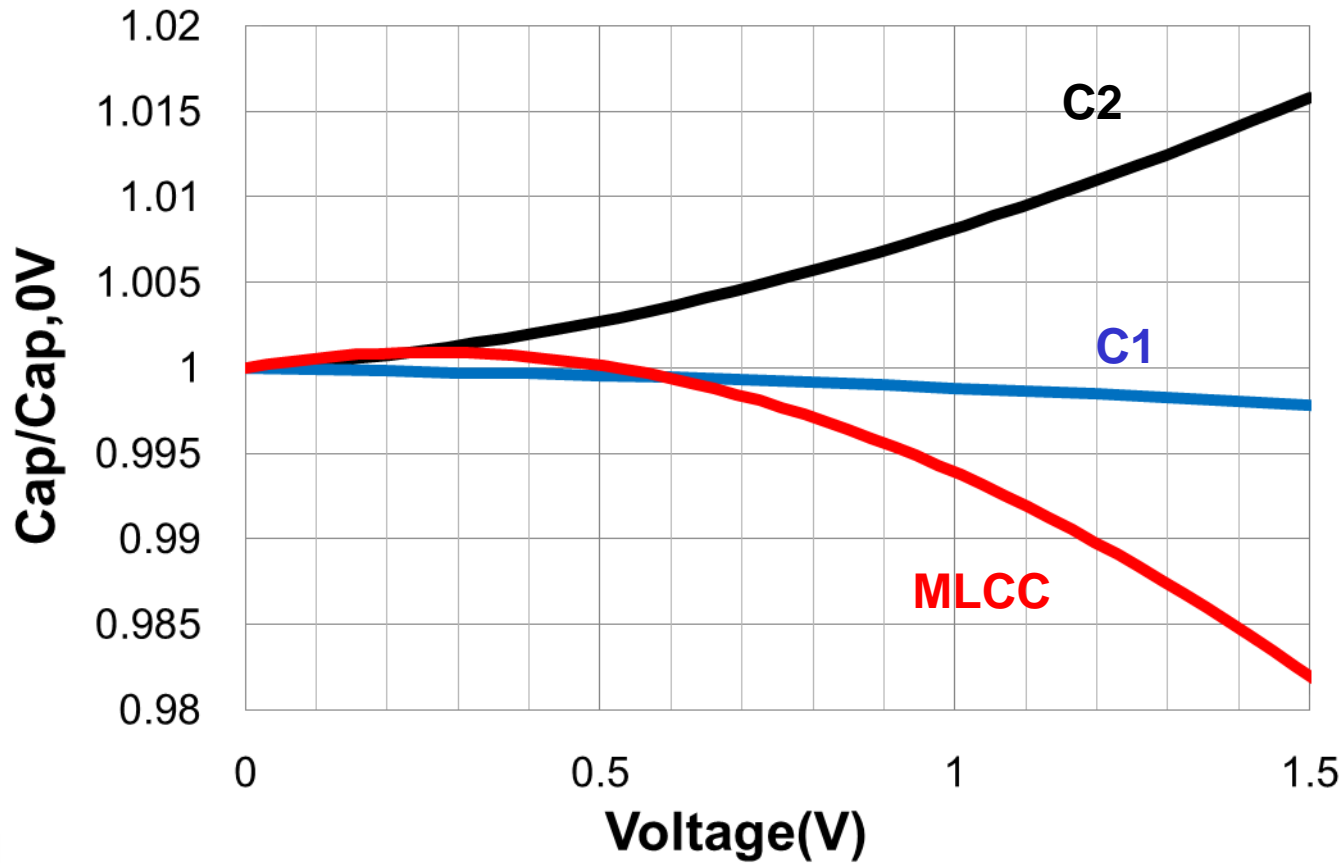
- **TSMC deep trench capacitor (DTC)**
- **Equivalent series resistance and inductance**
- **Surface mount capacitor**

TSMC DTC characteristics

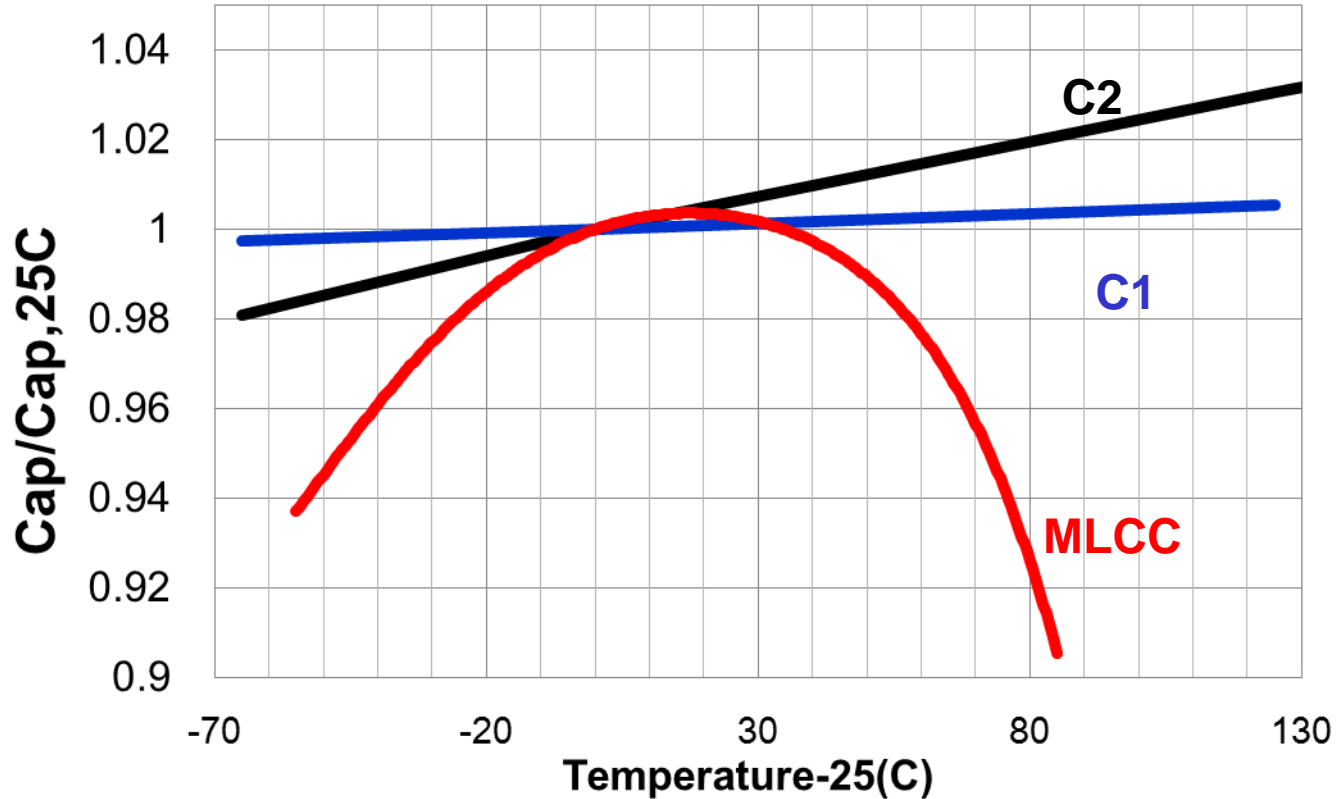
Density, nF/mm ²	Breakdown Voltage, V	TDDb, V	Operation Voltage, V
250	14.3	8	5.0
600	5.5	4	1.5
950	4.2	1.7	1.2
1500	5.1	1.6	1.2



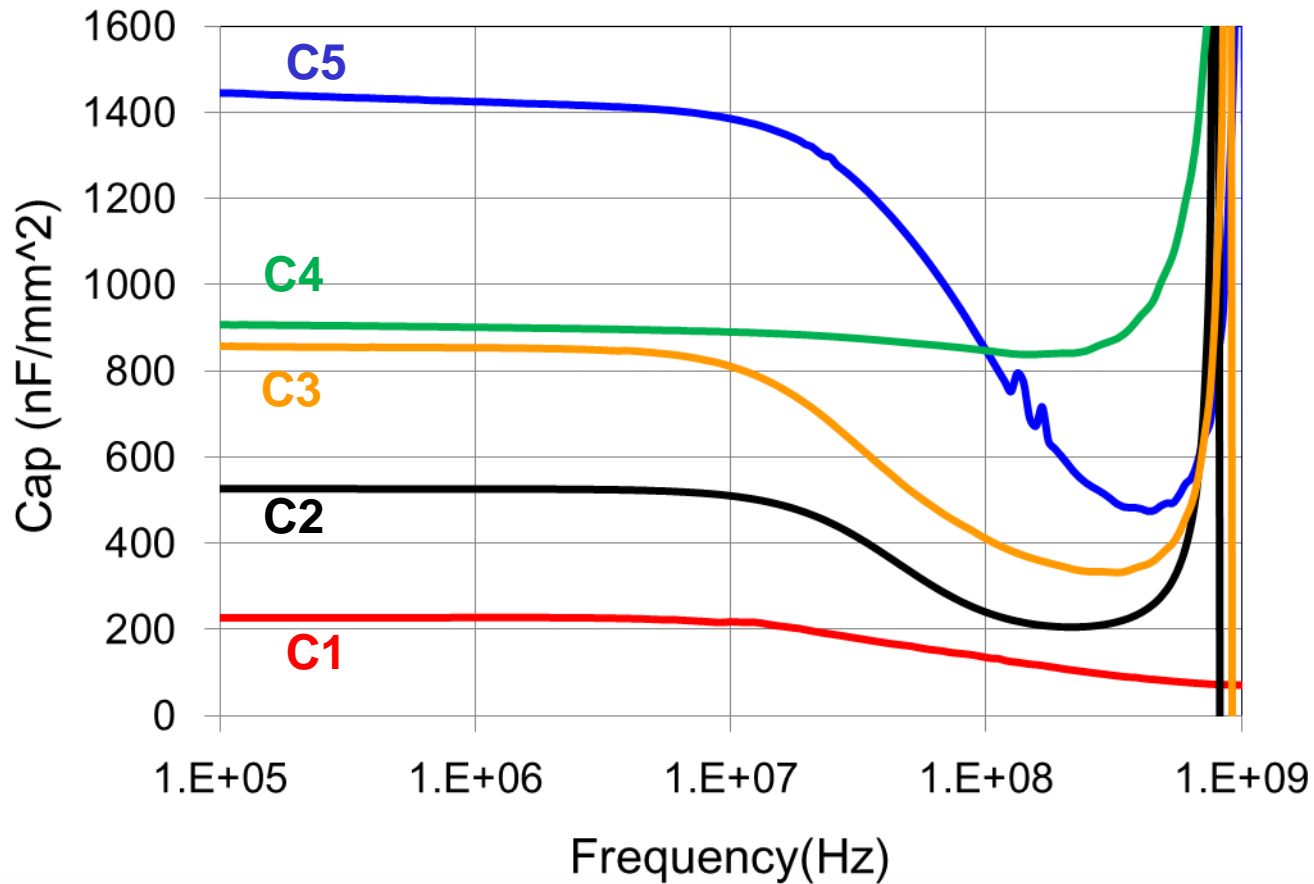
DTC Voltage Coefficient



DTC Temperature Coefficient



DTC Frequency Response

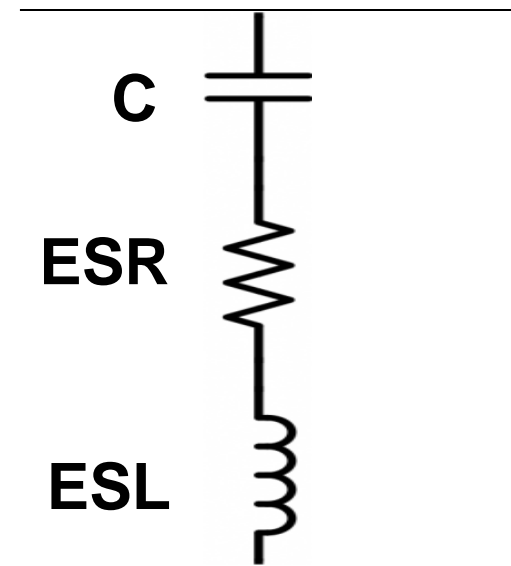


Outline and Summary

- **TSMC deep trench capacitor (DTC)**
 - 1500nF/mm² is demonstrated for 1.2V operation voltage.
 - TCC and VCC are better than commercial capacitor.
- **Equivalent series resistance and inductance**
- **Surface mount capacitor**

Capacitor in parallel

Single Capacitor

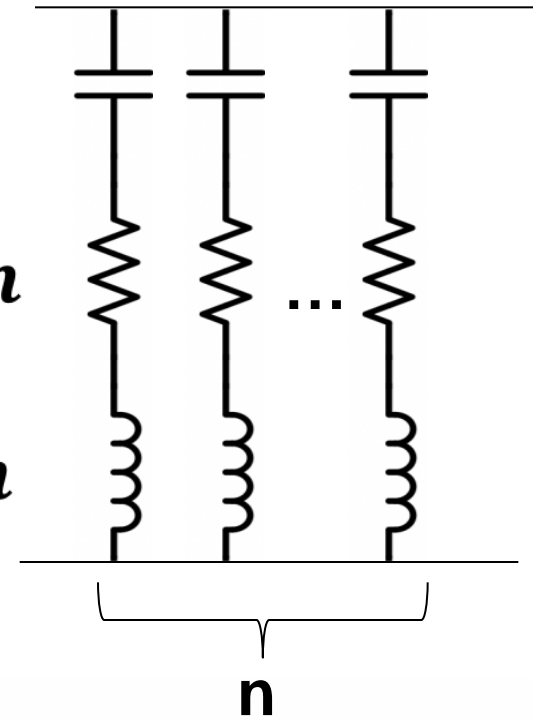


Parallel Capacitors

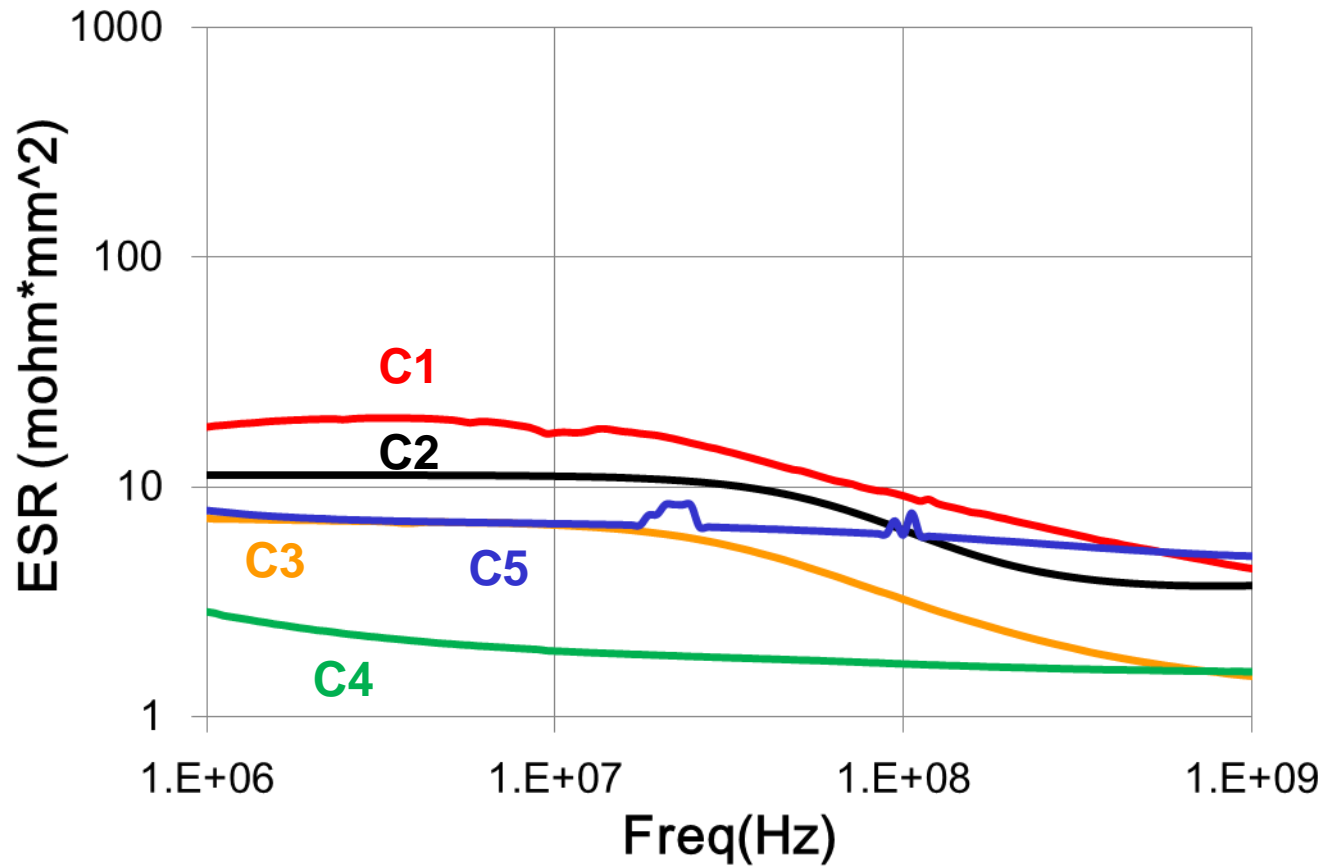
$$C_n \propto n$$

$$ESR_n \propto 1/n$$

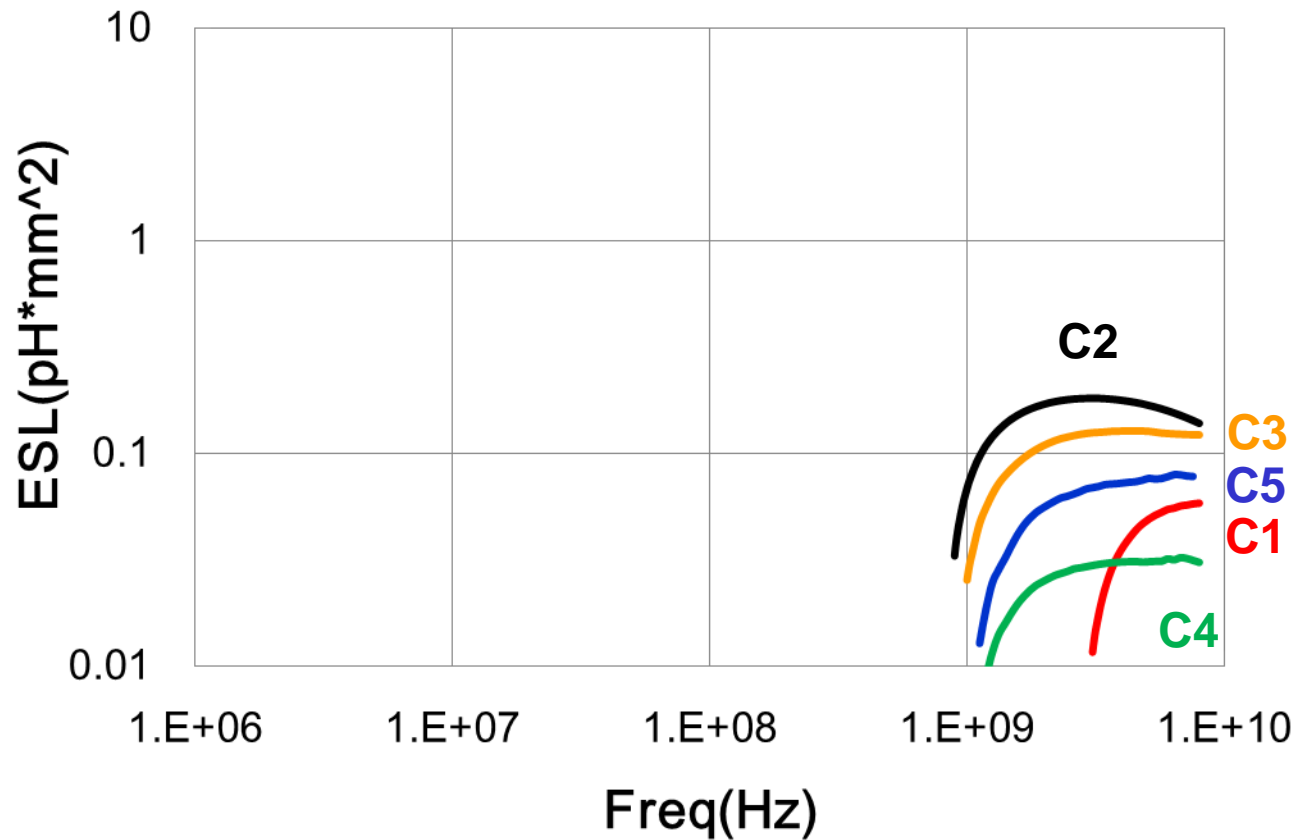
$$ESL_n \propto 1/n$$



DTC Equivalent Series Resistance



DTC equivalent series inductance

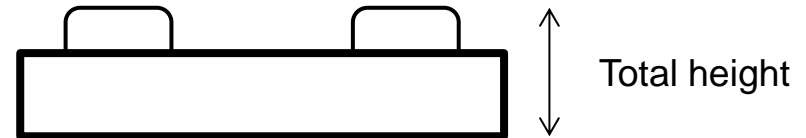
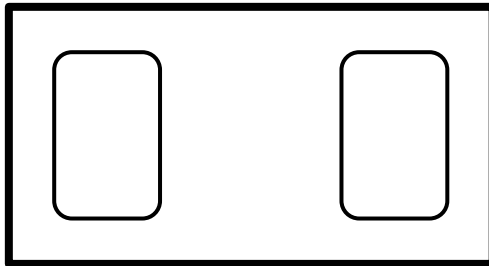


Outline and Summary

- TSMC deep trench capacitor (DTC)
 - 1500nF/mm² is demonstrated for 1.2V operation voltage.
 - TCC and VCC are better than commercial capacitor.
- **Equivalent series resistance and inductance**
 - Capacitor with in-parallel DTC cells can provide excellent ESR and ESL.
- **Surface mount capacitor**

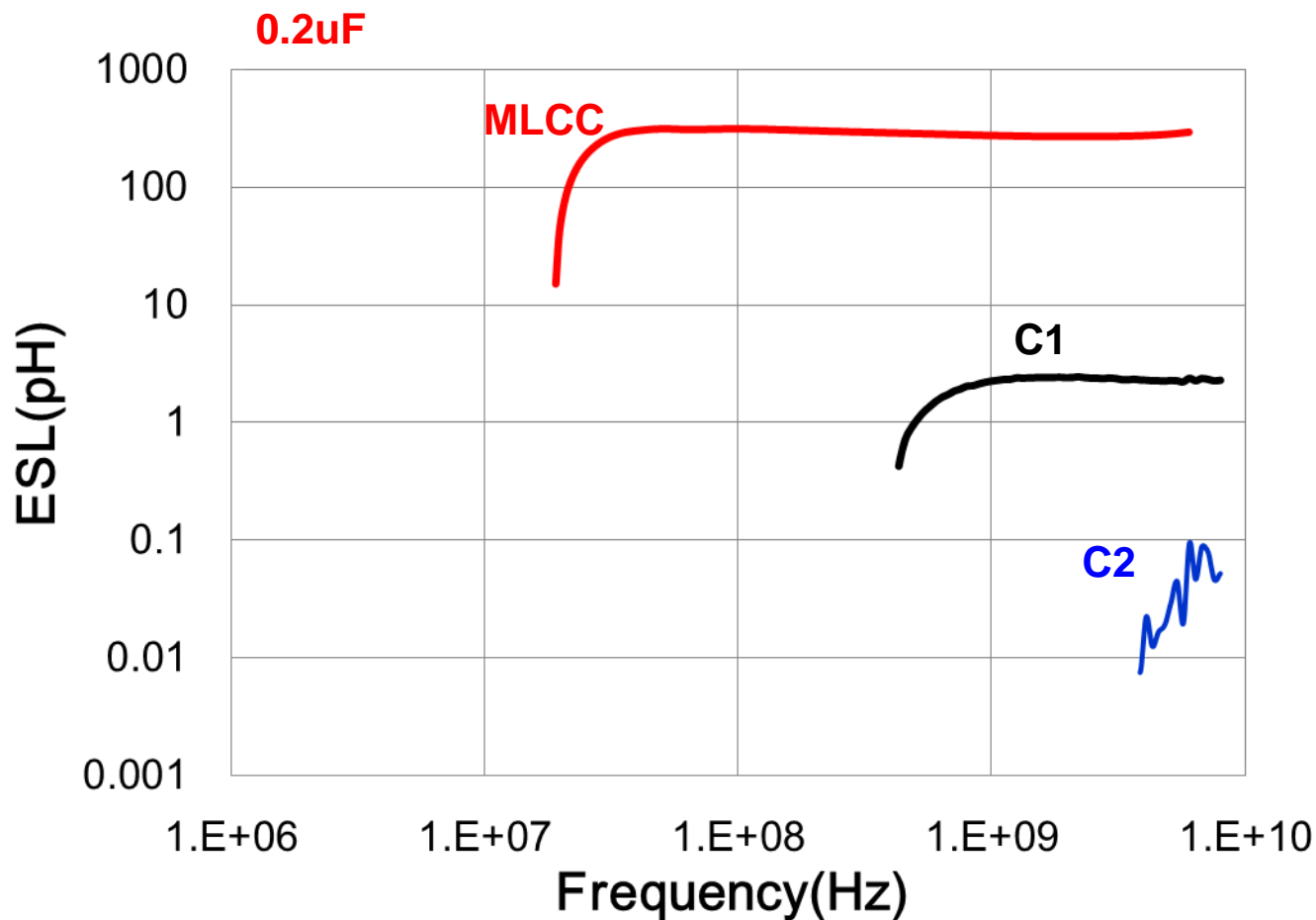
Surface Mount Capacitor

Top view

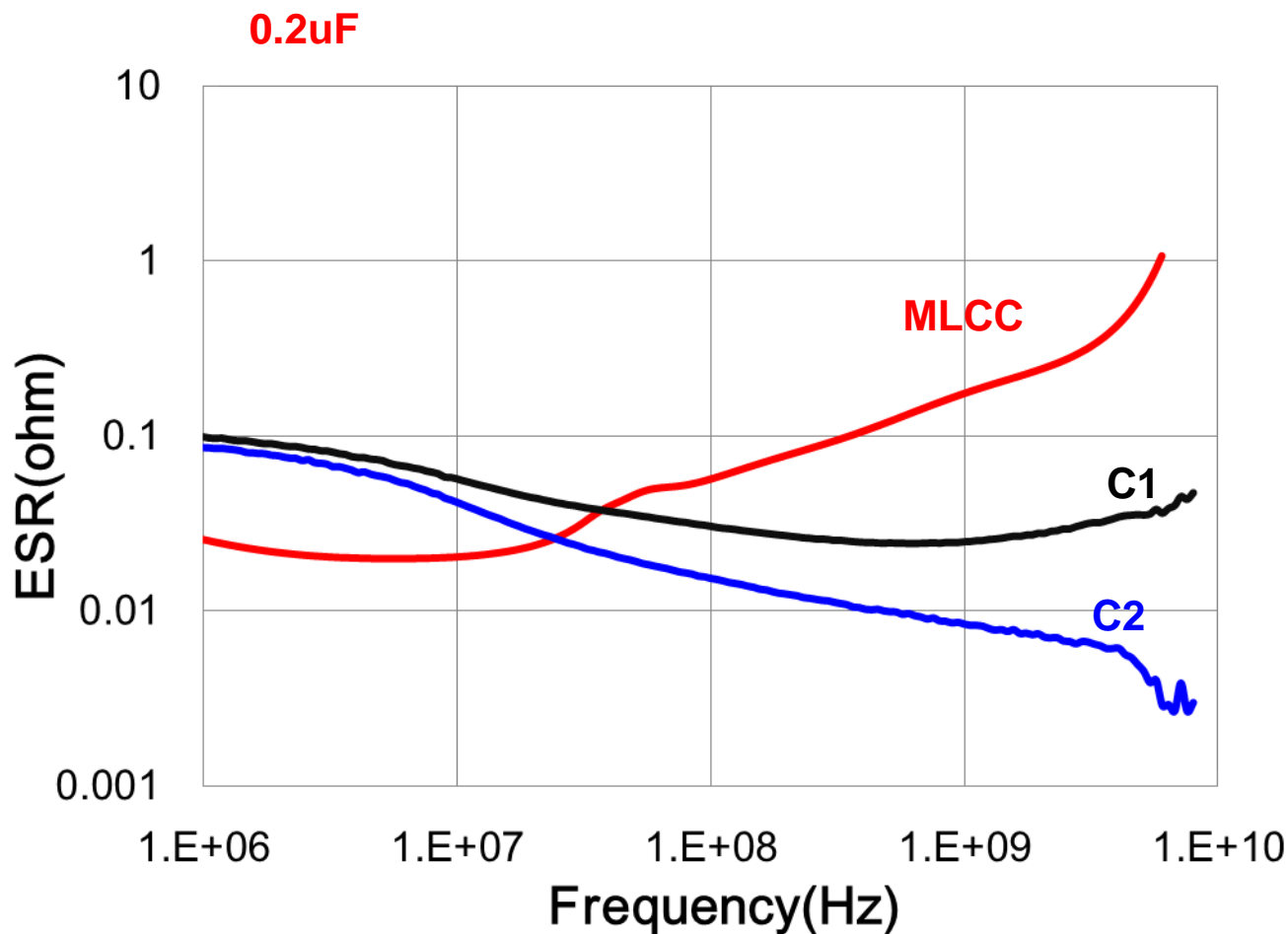


Ti/Cu/Ni/Sn Ag	In-line measures	X-SEM
Si THK	Avg 71.4um (69~73um)	63.3um
Joint THK	N/A	9.6um
Total Height	N/A	75.4um

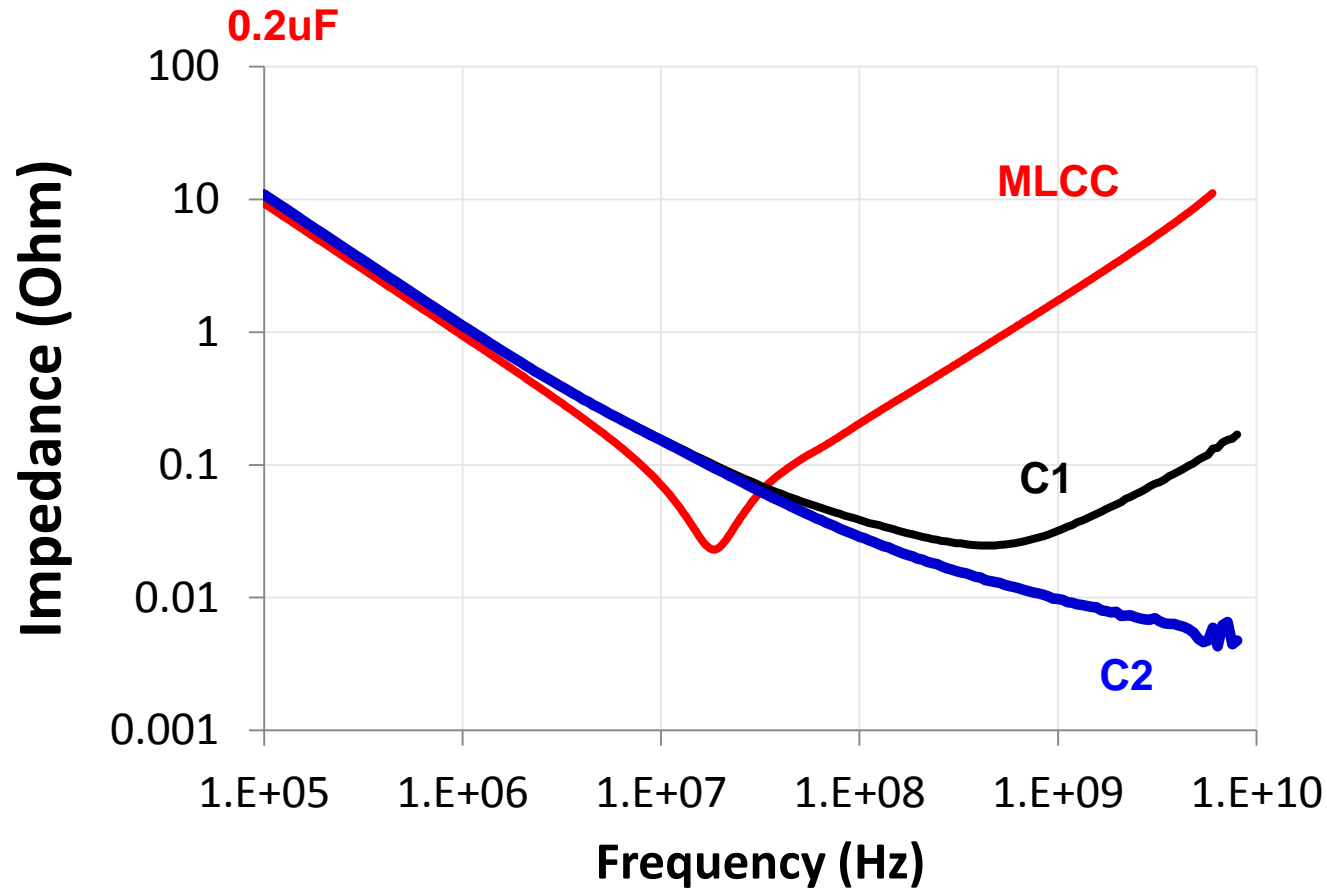
DTC Equivalent Series Inductance



DTC Equivalent Series Resistance



DTC Impedance



Summary

- **TSMC deep trench capacitor (DTC)**
 - 1500nF/mm² is demonstrated for 1.2V operation voltage.
 - TCC and VCC are superior to commercial capacitors.
- **Equivalent series resistance and inductance**
 - Capacitor with in-parallel DTC cells can provide excellent ESR and ESL.
- **Surface mount capacitor**
 - Low ESR and ESL can be achieved by interconnection optimization.
 - DTC process offers thin IPD thickness (<70um).