

# Benzocyclobutene as a dielectric spacer for field emission electron sources

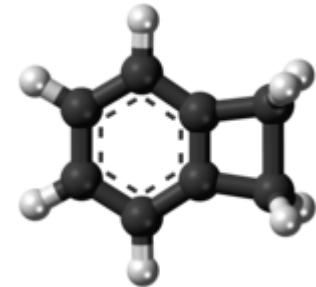
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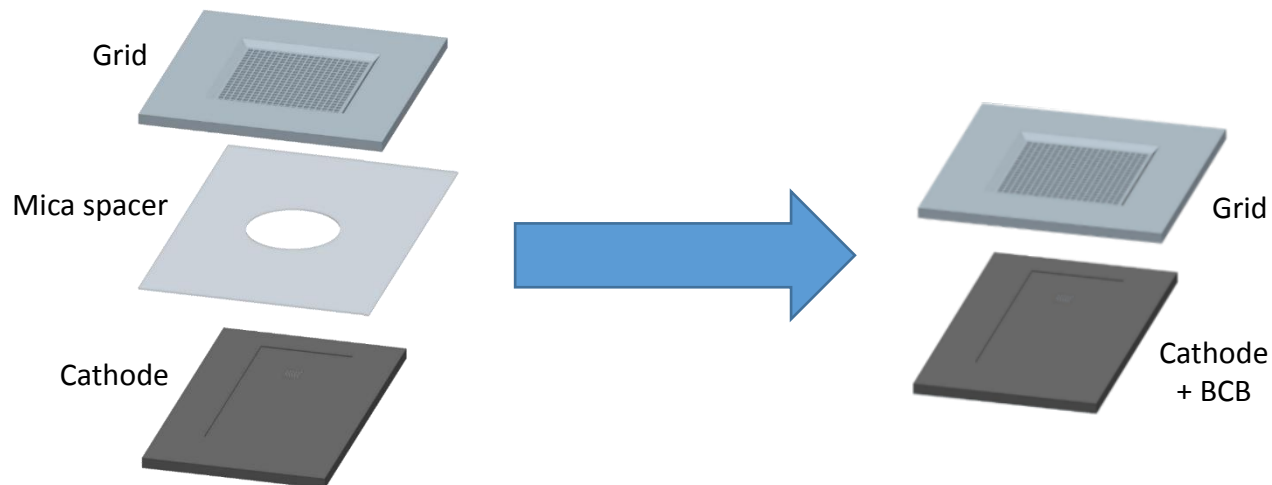
# 1. Introduction

- Benzocyclobutene (BCB) represents a family of thermosetting polymers developed by Dow Chemical
- BCB is a benzene ring fused to a cyclobutene ring with the chemical formula  $C_8H_8$
- BCB-based polymer dielectrics are low-k materials (dielectric constant 2.65) with a high electrical breakdown field strength ( $\approx 3 \times 10^6$  V/cm), high thermal stability ( $T_g > 350^\circ\text{C}$ ) and good planarization  
→ suitable dielectric material for fabrication of microelectronic and photonic devices



## 2. Use of BCB for field emission electron sources

- Because of its characteristics it can be used as an integrated insulator for field emission electron sources
- Sources can be reduced to only two components instead of three components



## 2. Use of BCB for field emission electron sources

### ➤ Spin-coating

- Different coatings with different viscosities and thus with different possible layer thicknesses
- Thickness also depends on rotation speed

### ➤ Curing

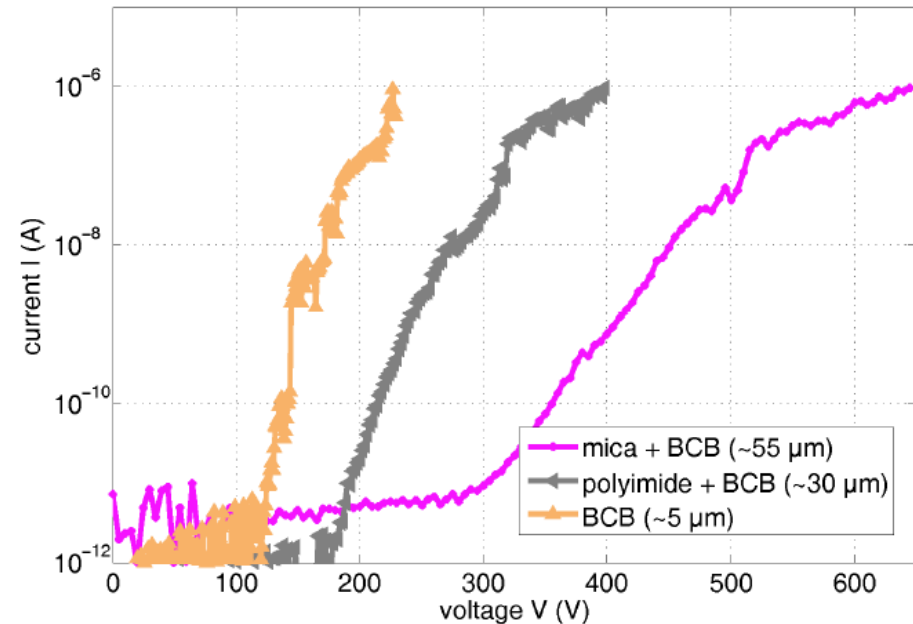
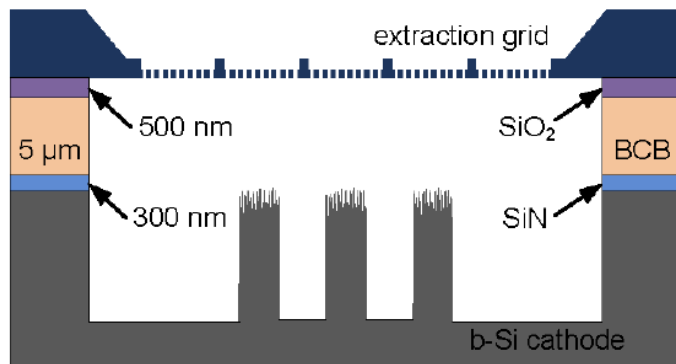
- Softcure (at 210°C, ~75% conversion) → good adhesion to metals and polymers for successive multiple coatings
- Fullcure (at 300°C, (>95% conversion) → highly resistant to common wet chemistry like Acetone, BOE and TMAH

### ➤ Thin-film patterning

- Dry etch with O<sub>2</sub> and a flourine containing gas
- selectivity to photoresist 1:1
- high selectivity to metal

Spin Speed (RPM)	CYCLOTENE 3022-57
1000	13.8
1500	10.7
2000	9.04
2500	7.97
3000	7.21
3500	6.65
4000	6.20
4500	5.84
5000	5.55

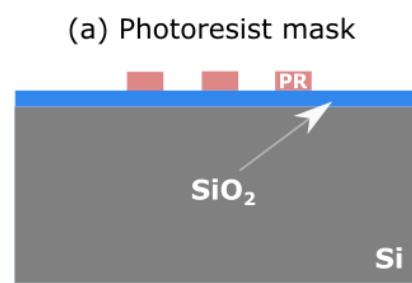
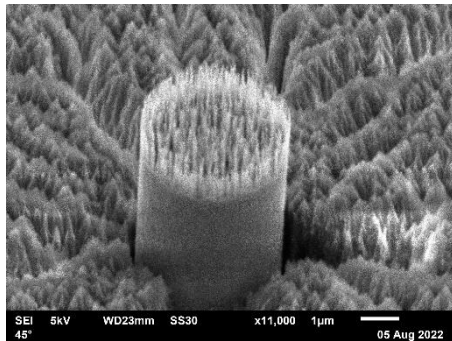
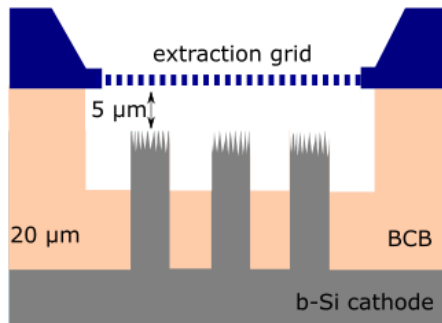
### 3. Previous work



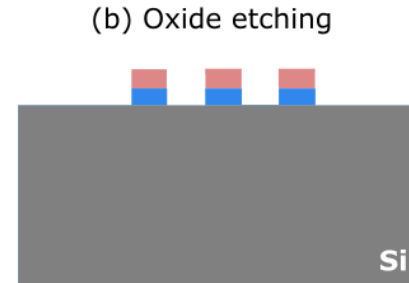
- Reduction of operational voltage
- But lifetime of samples only several minutes

<sup>1</sup> C. Prommesberger, C. Langer, R. Lawrowski, and R. Schreiner, "Benzocyclobutene as a novel integrated spacer material in a field emission electron source", Proc. of 30th IVNC, 2017, pp. 192-193.

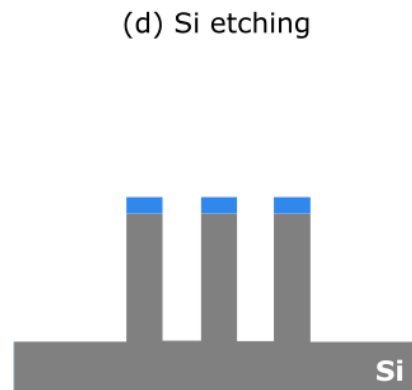
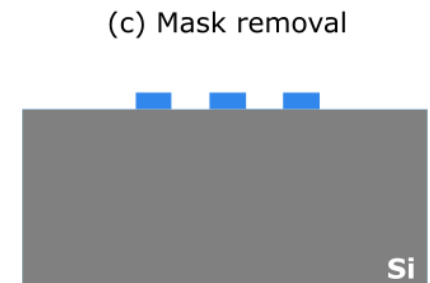
## 4. New design of cathode with integrated spacer



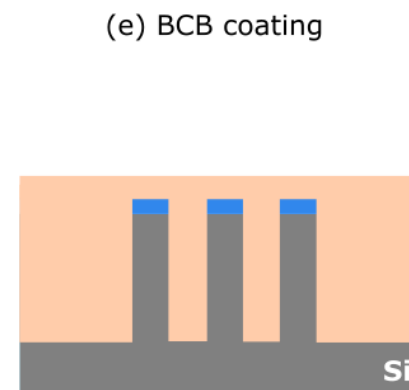
(d) Si etching



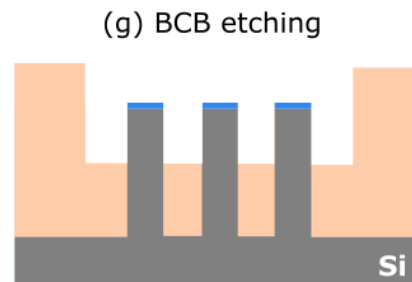
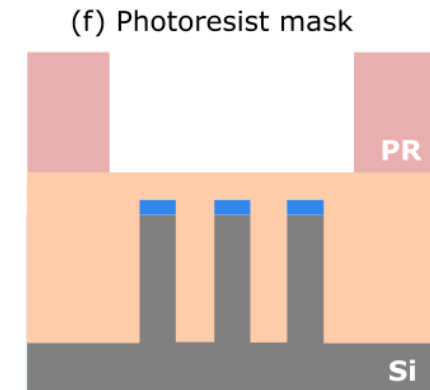
(e) BCB coating



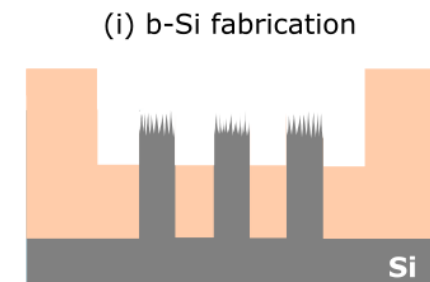
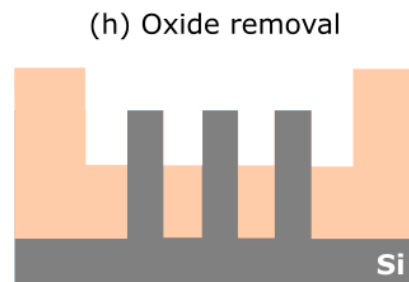
(g) BCB etching



(h) Oxide removal

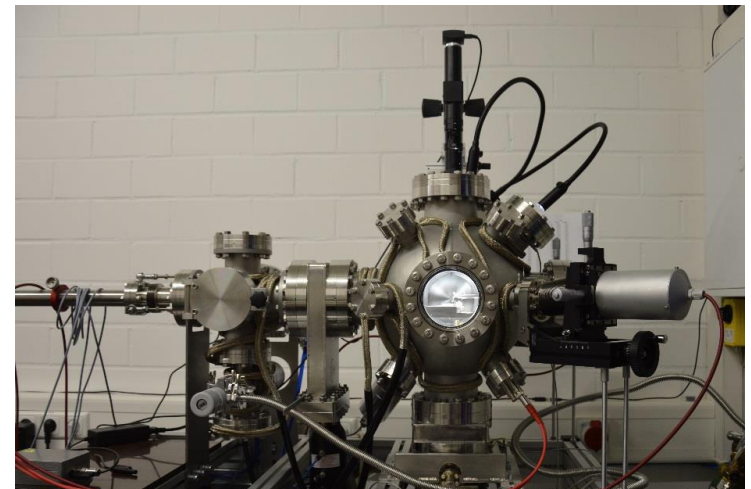
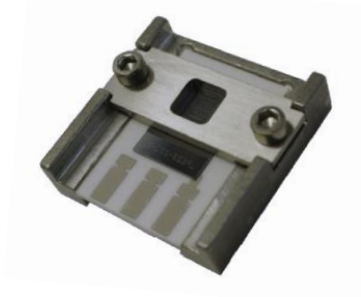
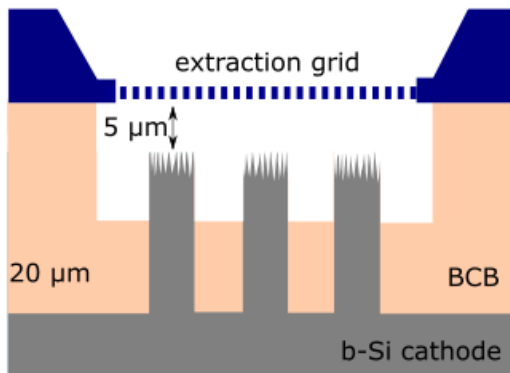


(i) b-Si fabrication



## 5. Measurement results

- Measurement under UHV condition ( $10^{-9}$  mbar)
- voltage was kept every 100V for one hour
- Longer creepage distance  $\rightarrow$  samples show a longer lifetime
- Limit of measurement set-up at 900V, because of bending of grid



## 6. Conclusion

- BCB is a suitable dielectric spacer for field emission electron sources
- It can be easily processed and combined with silicon emitters
- Lower distances between cathode and grid are possible



# Thank you for your attention!