

Research and Development of an Electret Micro Pattern Gaseous Detector

SEED MONEY PRESENTATION- SCIENCE WEEK

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CHRISTOPH JAGFELD

AG BIEBEL



LMU

LUDWIG-
MAXIMILIANS-
UNIVERSITÄT
MÜNCHEN



Electrets

- Electret (Wikipedia):
 - Dielectric material with a permanent electric charge
 - Dielectric material with a permanent dipole polarization
- ⇒ Permanent electric field

kids birthdayparty

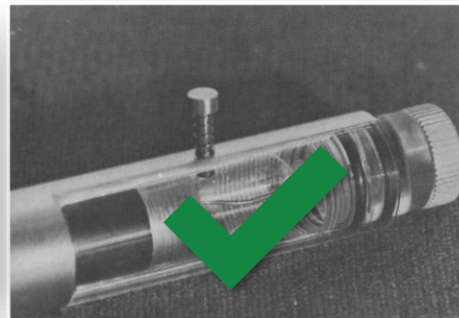


<https://kidsweb.wien/experimente/elektrostatische-ladung/>

microphone

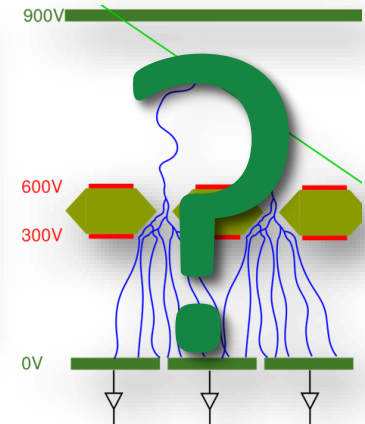


dosimeter



https://www.researchgate.net/figure/Pen-dosimeter-with-an-electret-charging-facility_fig2_256551723

gaseous detectors

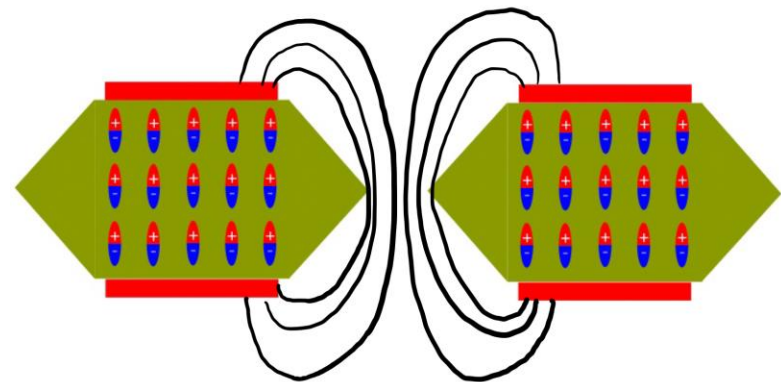
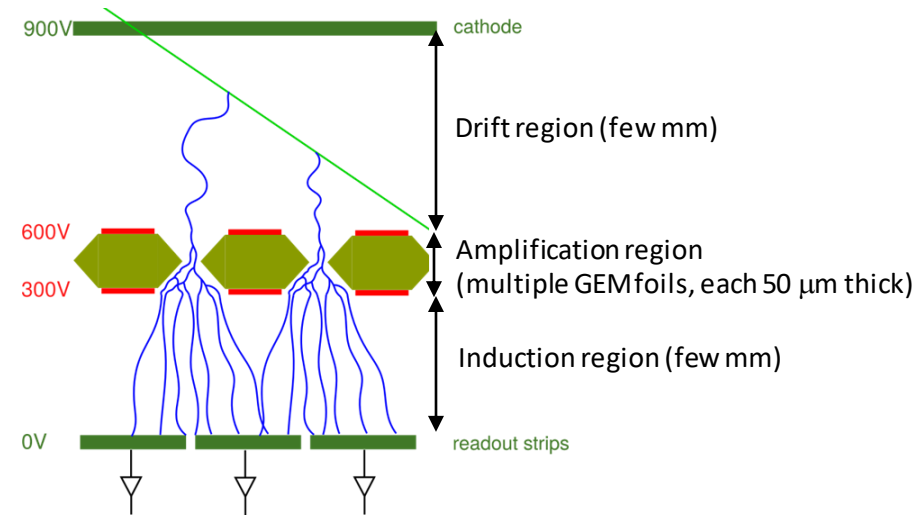


⇒ Can electrets be used for high precision particle detection using micro pattern gaseous detectors?

⇒ Development of a self sustained detector system

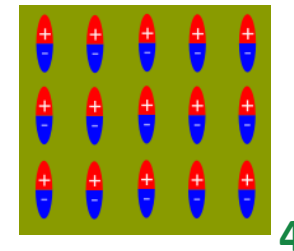
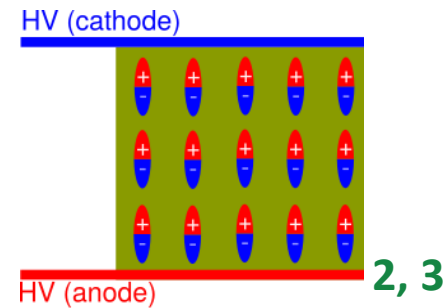
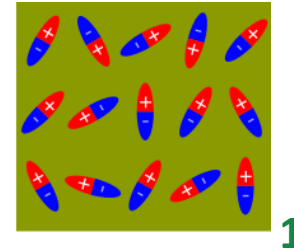
Transition to an Electret GEM Foil

- Working principle of a GEM Detector:
 - See previous talk by Katrin Penski
 - Status quo:
 - External high voltage supply
 - Expensive, heavy weight, ...
 - Our concept:
 - “Freeze” the electric field in the GEM Foil
 - ⇒ Usage of an **electret** instead of “neutral” Kapton
- ⇒ No need for external high voltage supply



Creation of an Epoxy Electret Foil

1. Base material: 2 component epoxy (easily manageable)
 - Bipolar medium
 - Unsorted dipoles (normally)⇒ No electric field
2. Application of an external electric field on unhardened epoxy (+heating)
⇒ Orientation of the dipoles along field lines
3. Hardening (+cooling) of the epoxy under applied high voltage
4. Oriented dipoles
⇒ Frozen electric field 😊



Epoxy Electrets – State of the Art (Literature)

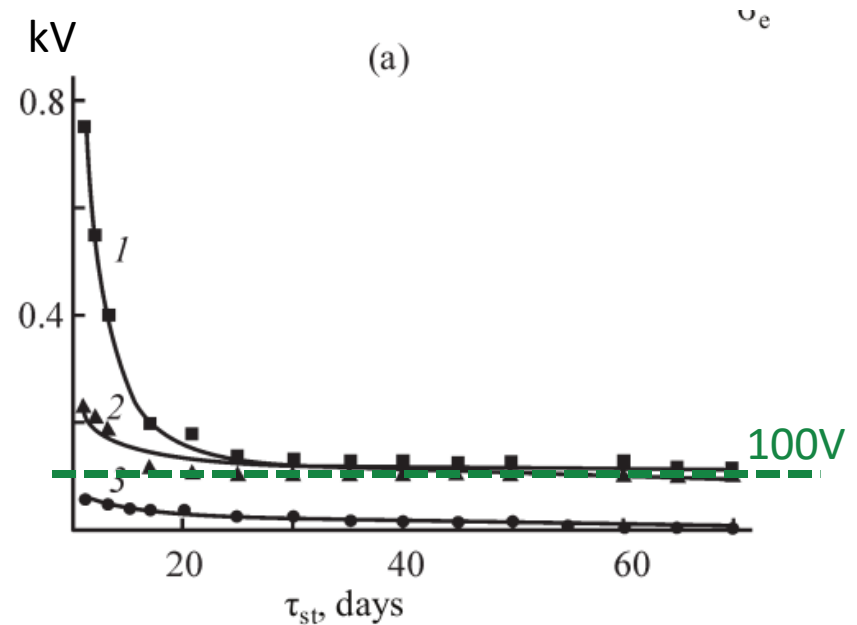
- Stabilized voltage of approx. 100V can be reached (Mochalova, et al.)

⇒ Difficulties:

- Used epoxy D.E.R. 331 can not be bought in small quantities
- Hardener hard to handle

- Increase of the stabilized voltage by doping with LiClO_4 salt

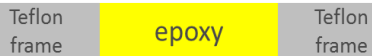
Liu, Yu-Cheng & Aoyagi, Yasuhiro & Chung, Deborah. (2008).
Development of epoxy-based electrets. *Journal of Materials Science*.
43. 1650-1663. 10.1007/s10853-007-2391-2.



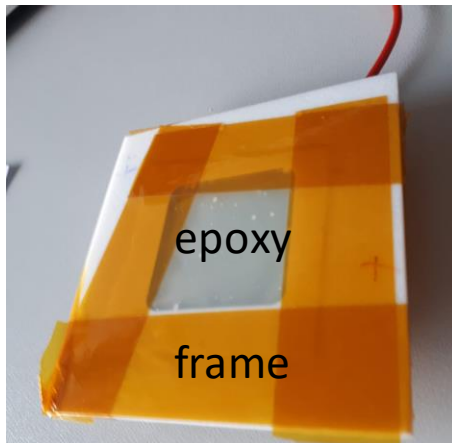
Taken from: Mochalova, E.N., Galikhanov, M.F. & Mikryukova, Y.K.
Electret and Strength Properties of Polymeric Materials Based on
Epoxy Oligomer and Amine Curing Agents. *Russ J Appl Chem* **92**,
1492–1498 (2019). <https://doi.org/10.1134/S1070427219110041>

Electret Production (our Attempts)

Teflon foil



Teflon foil



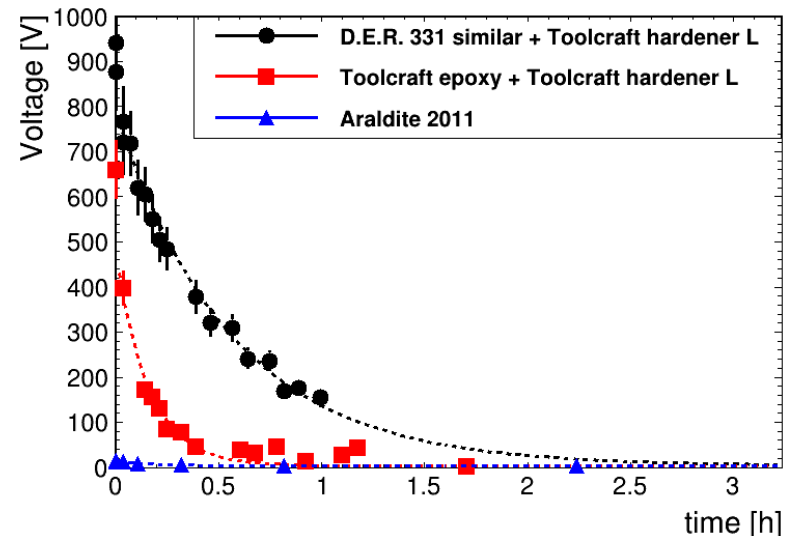
1. 2-component epoxy casted into Teflon mold
2. Teflon mold sealed by Teflon foil
3. Application of an external electric field (up to 80 kV/cm) during Epoxy hardening
4. Voltage measurement using an electric field meter (Voltage determined capacitively, generating voltmeter)

Investigated Epoxy Materials

- Used epoxys:
 - Toolcraft
 - Poly-(Bisphenol A-co-epichlorhydrin (similiar to D.E.R 331))
 - Araldite 2011
- Used hardener:
 - Toolcraft hardener
 - Araldite hardener

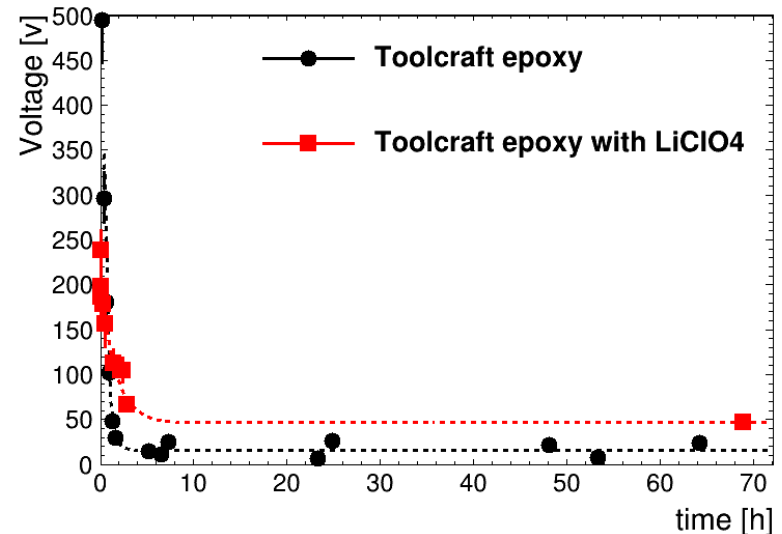
⇒ Strong dependence on the epoxy material

⇒ No high long term stable voltage reached yet



Doping with LiClO₄

- Admixture of pestled LiClO₄ to heated epoxy (80 °C)
(LiClO₄ hard so solve in epoxy)
- ⇒ Arrangement of the ions according to the electric field
- ⇒ LiClO₄ increases the long term voltage
- ⇒ 40 V reached



Different Epoxy – Hardener Mixing Ratios

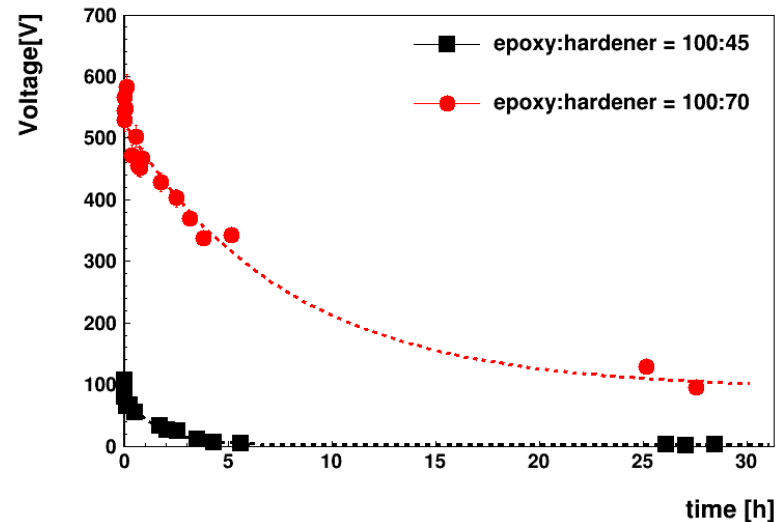
- Variation of the epoxy – hardener mixing ratio

⇒ Voltage dependence on the amount of hardener

⇒ Addition of more hardener

⇒ Stabilized voltage of approx. 150 V reached
(1.55 times increased amount of hardener

⇒ approx. drift voltage in GEM



Summary and Outlook

- Epoxy material can be polarized
 - Stabilized voltage high enough for the ion – electron separation voltage in the drift region
 - Stabilized voltage not high enough for amplification voltage yet
- Outlook:
 - Investigation of different epoxies and hardener
 - Different electret production technique: electret charging via corona discharges
 - Setup of an electret GEM detector
 - Removal of surface charges

⇒ More challenging as expected, but fun to work on 😊

Thank You!



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