The influence of humidity on perovskite niobate dielectrics

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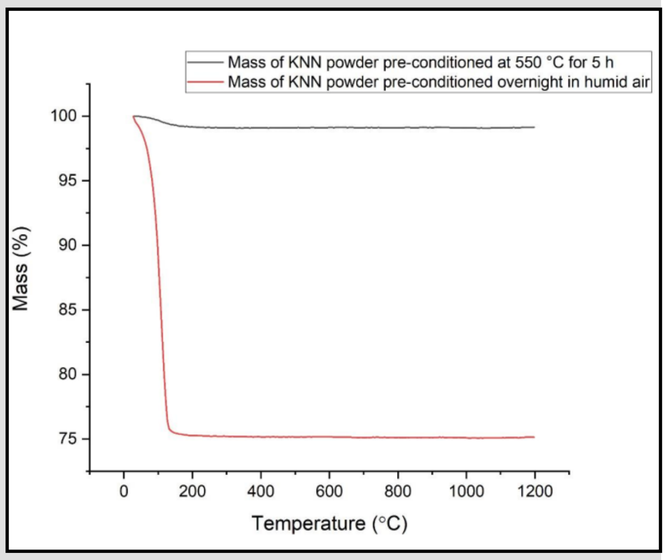
Summary

- Alkaline-Niobate (KNN) Ceramics are highly influenced by ambient humidity in their dielectric properties.
- Publications often don‘t incorporate this fact and thus the measured values are not always comparable [1-3].
- Measuring reliable values is a difficult task because no commercial measurement setups are available.
- A cheap and easy measurement system was invented, based on an Arduino microcontroller and a sample cell with saturated salt solutions for maintaining the different humidity levels.

Experimental Data

Fig. 1: TGA measurement of a dry and a humidified powder sample. Even by doing the measurement right after taking it out from the furnace, there is a slight humidity uptake in the dry sample on the way from the chamber furnace to the TGA system as can be seen in the black curve.



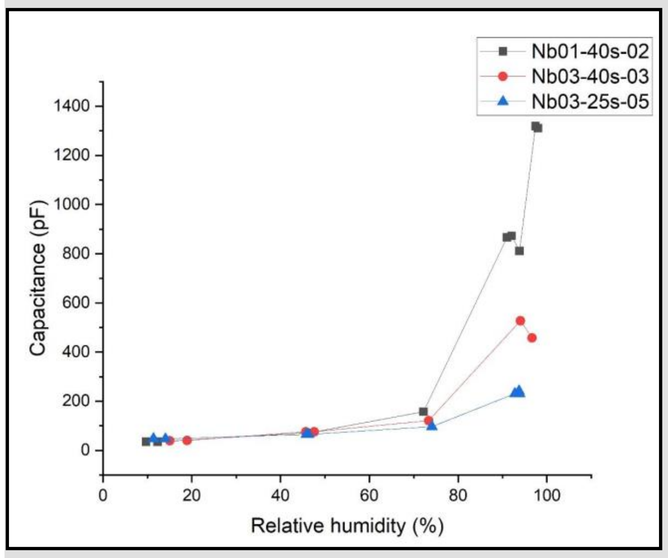
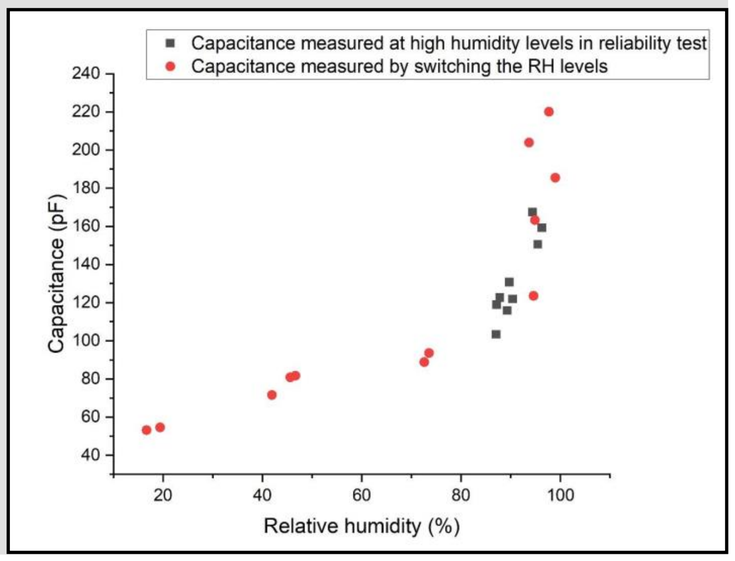


Fig. 2: Capacitance measurement of different EPD samples at various humidity levels. As seen in the region above 80 % rel. Humidity there is a significant error in the measurement. But in comparison to the extremely high values, there is clearly a trend identifiable.

Fig. 3: By comparing the measurements of a sam-ple in alternating high and low humidities with a sample measured multi-ple times only at high hu-midities the reliability of the measurement setup and the used method can be proven and an error of about 15 % at high levels can be estimated.



References

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[2] S. Zhang, R. Xia, T. R. Shrout, *Journal of Electroceramics* **2007**, 19, 251
[3] T. Shao, H. Du, H. Ma, S. Qu, J. Wang, J. Wang, X. Wei, Z. Xu, *J. Mater. Chem. A* **2017**, 5, 554.
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Sample Preparation

- KNN ceramic powders were prepared by a sol-gel reaction similar to [4].
- An 1:1 ratio of sodium and potassium was maintained in the niobite.
- To measure the dielectric properties thin films of about 100 µm were produced by an EPD process
- Film samples showed a high porosity, were not sintered but stabilized with various amounts of PMMA.

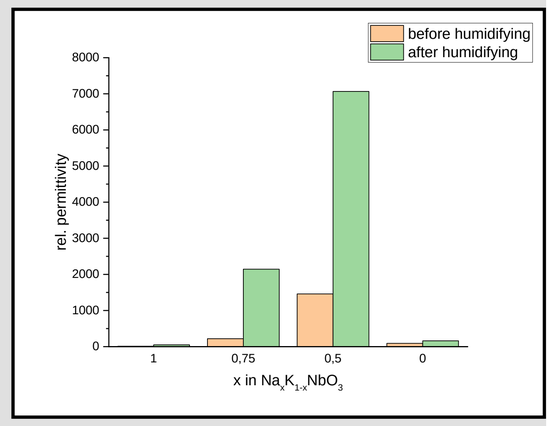
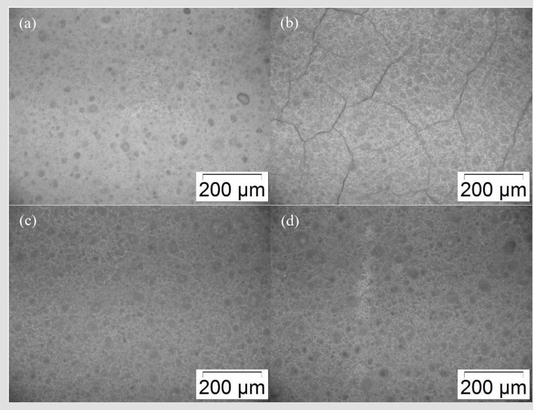


Fig. 4: Comparison of the rel. permittivity measured ambient and humidified conditions. The samples varied in the composition, regarding their ratio of sodium and potassium in the niobate.

Figure 5: Microscopic images of KNN composite layers with a 10 times magnification. From a to d in different time intervals between suspension preparation and deposition (1,14,29,37 min). (a) and (b) had a deposition time of 40 while (c) and (d) only had 25 s. It seems there is a slight agglomeration in this timeframe which in this case was beneficial for the layer quality and deposition speed.



Measurement Setup

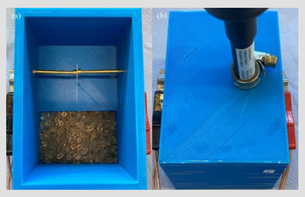


Fig. 6: First sample chamber design, using an external humidity sensor and RCL-meter.

- No commercially available setup for the desired measurement
- First run: a 3D printed chamber with contacts for an external measurement system
- Improvement: A microcontroller setup with build-in sensors allows automatic and dynamic measurements
- An exchangeable sample chamber provides a high throughput system by simultaneously conditioning the samples in several chambers

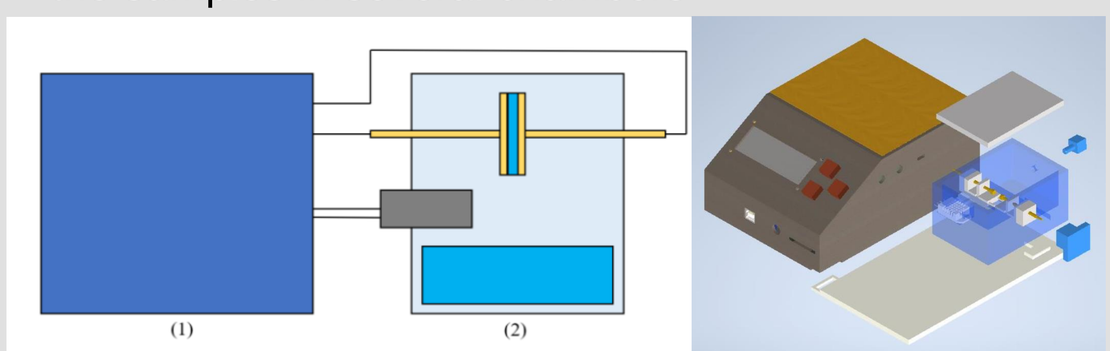


Fig. 7: schematic of the new setup using an Arduino and an exchangeable sample chamber with included sensors.

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