Analysis of Poisson Ratio Data in Piezo Actuator Stacks

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What's the Poisson Ratio?
Why is it important?

Background

- "Piezo-stack": A highly incompressible material
  - Stretches very minimally under low temperatures
- Poisson Ratio ("ν"): (Ratio of transverse strain):(ratio of axial strain)
  - Transverse = compressed; axial = tensile
- Potentially useful for data analysis and comparison
  - Strain measurement experiments
  - Replace unstable data

Background

- Ratio of compressed and tensile strains
  - Tensile ('T') and compressed ('C') direction
  - 'GF' = gauge factor
  - 'SG' = strain gauge
  - 'ε' =strain

$$\epsilon \times GF = \left(\frac{\Delta R}{R}\right)$$

$$\epsilon_T = \frac{\left(\frac{\Delta R}{R}\right)_T}{(GF)_{SG}}$$

$$\epsilon_C = \frac{\left(\frac{\Delta R}{R}\right)_C}{(GF)_{SG}}$$

Experimental Set-up

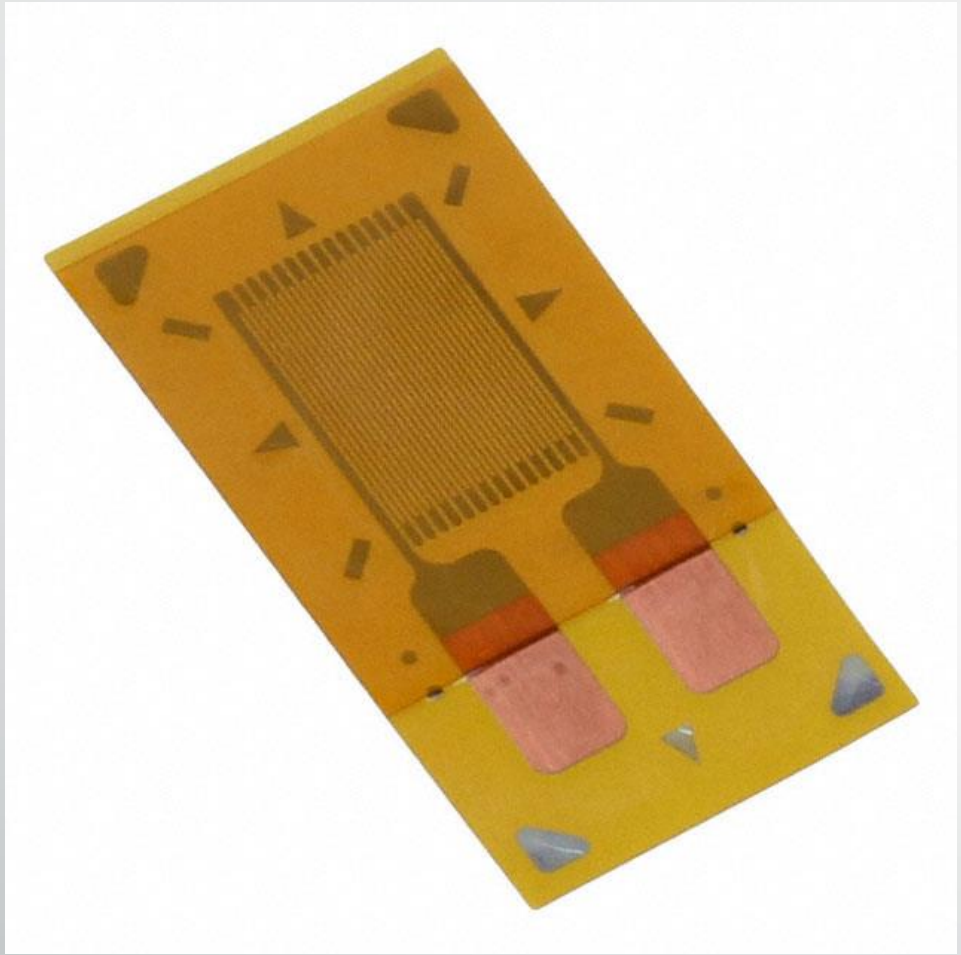
- Piezo stack is glued with varnish on a small metal bar
- Two strain gauges are glued with “stycast” onto the piezo-stack
- The whole setup is then put in a cryostat
  - Piezo-stack is ramped with different voltages to induce change in resistance

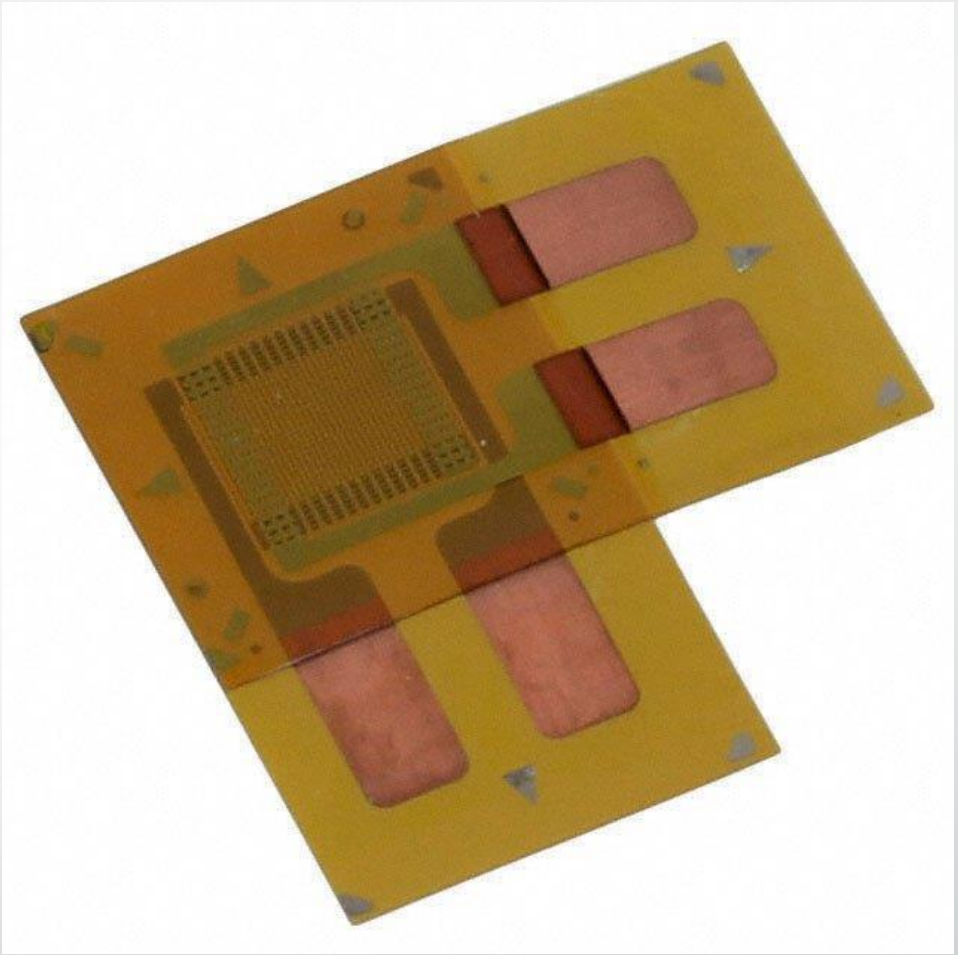
- 0-130V
- 2 strain gauges
- Piceramic

1st Setup

- -40-40V
- 1 Cross Strain Gauge
- Piezomechanik

2nd Setup



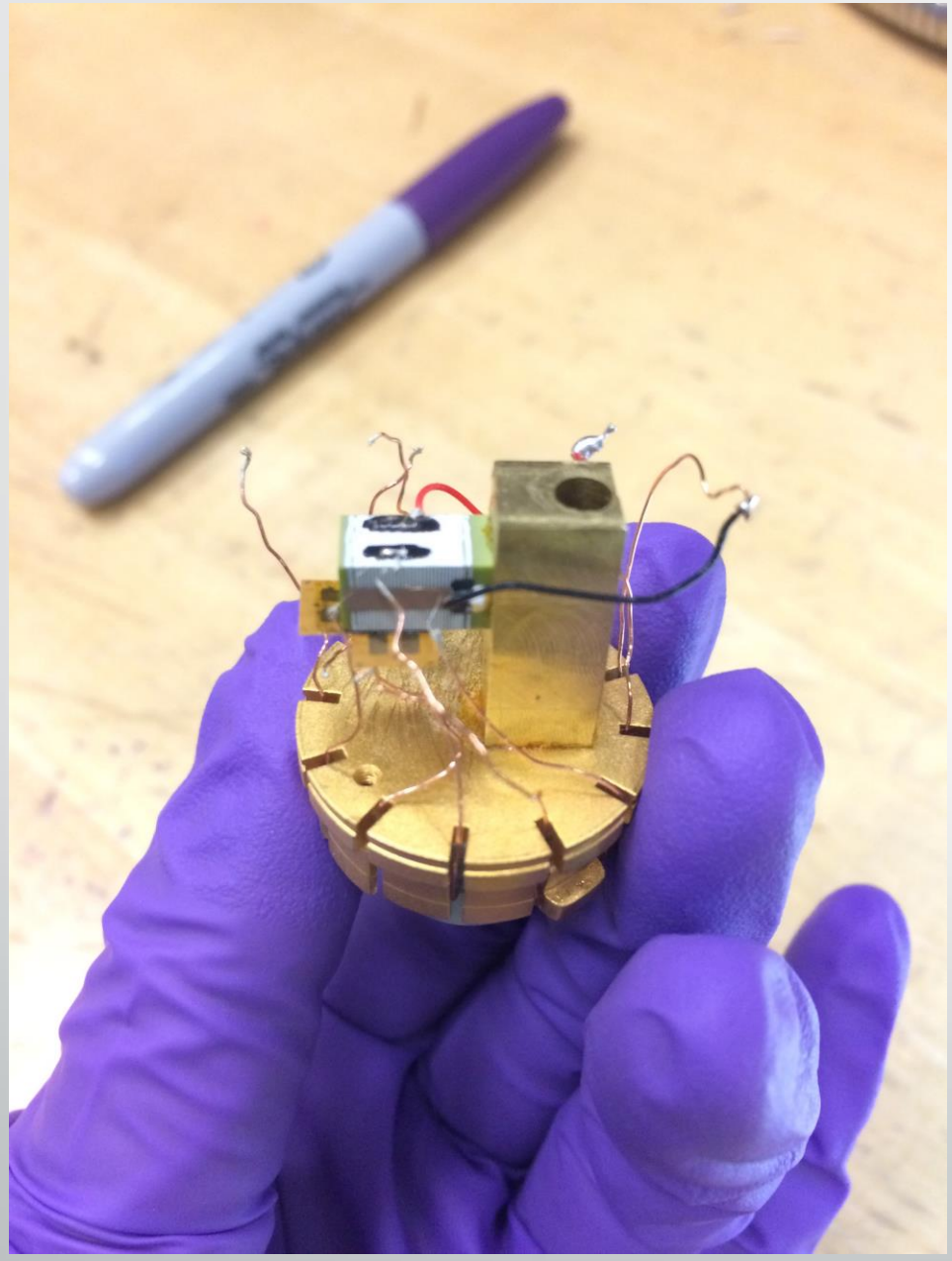


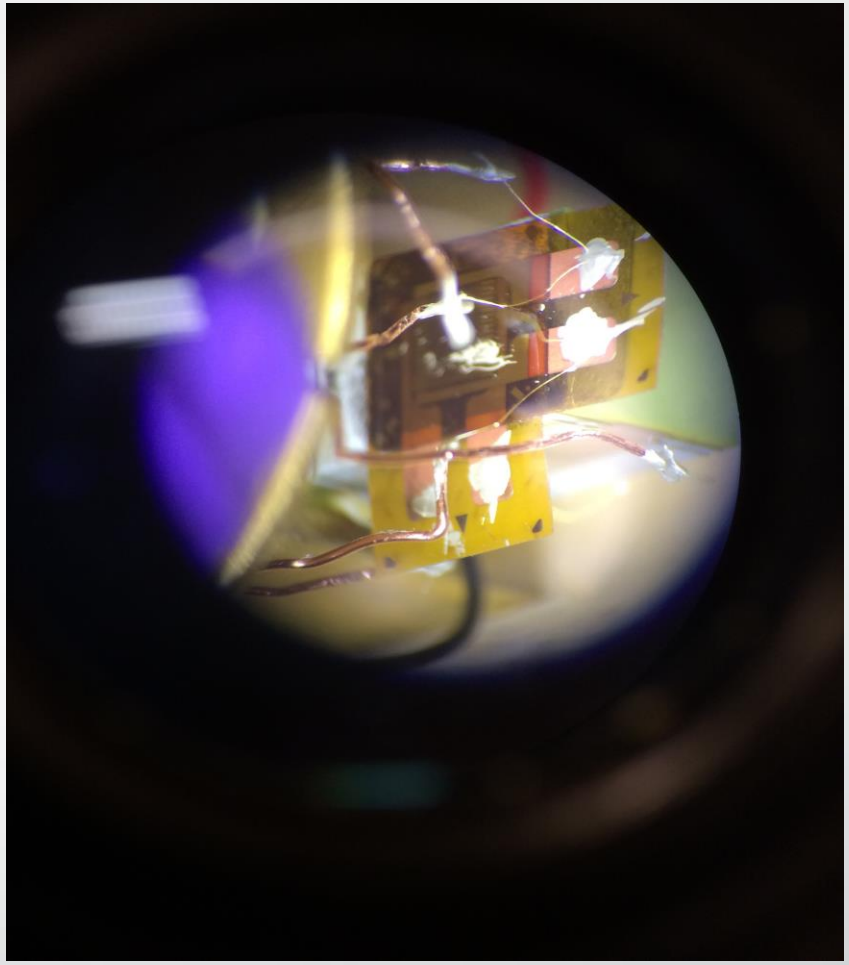
1st Setup

2nd Setup

1st Setup


USER BRIDGE
12
13
14
3I-
3V+
3V-
11
10
9
3I+
2V-
2V+
1I+
1I-
1V+
3
4
5
2I-
2I+
1V-
8
7
6





2nd Setup

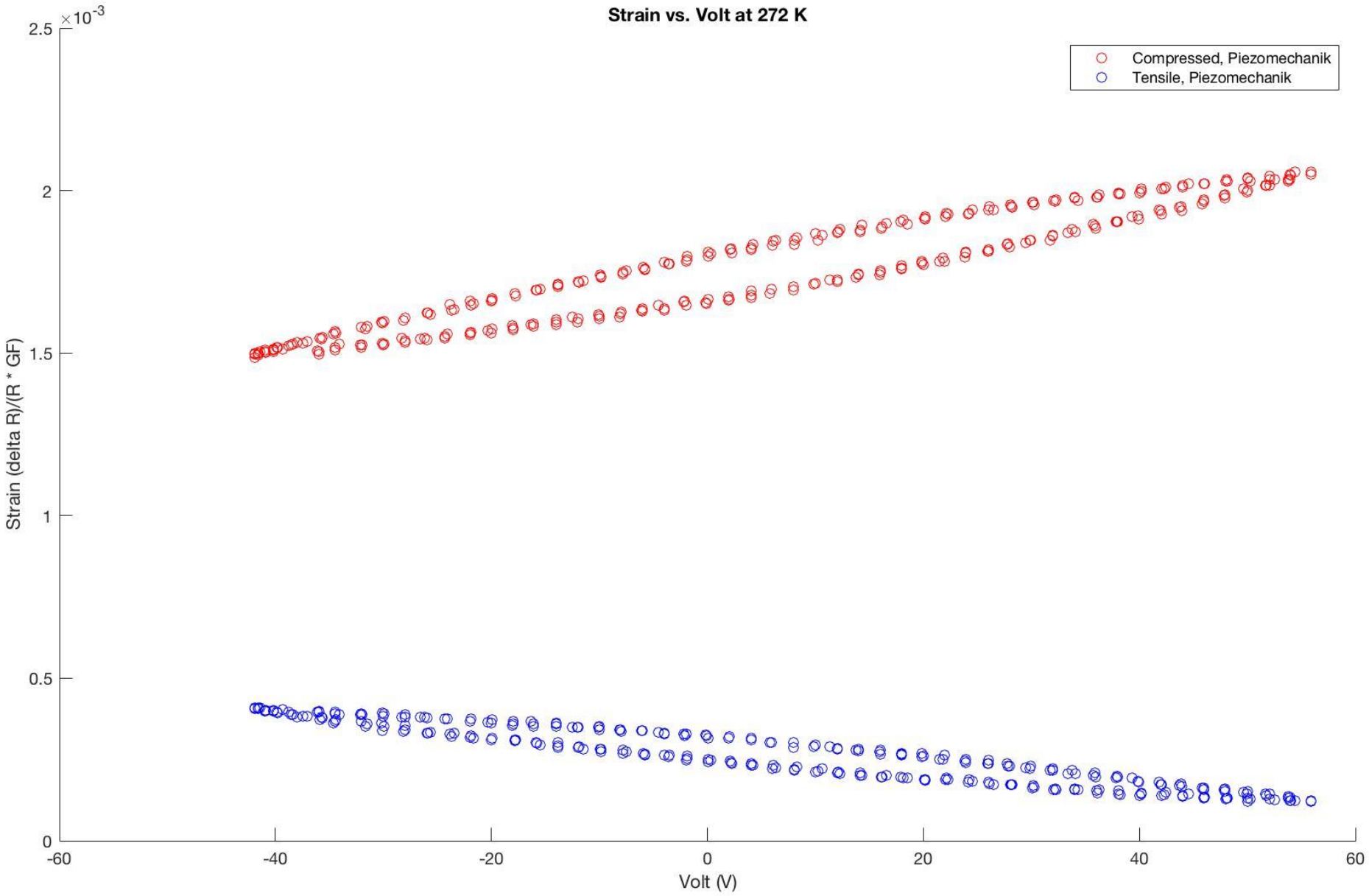
Measurement Procedure

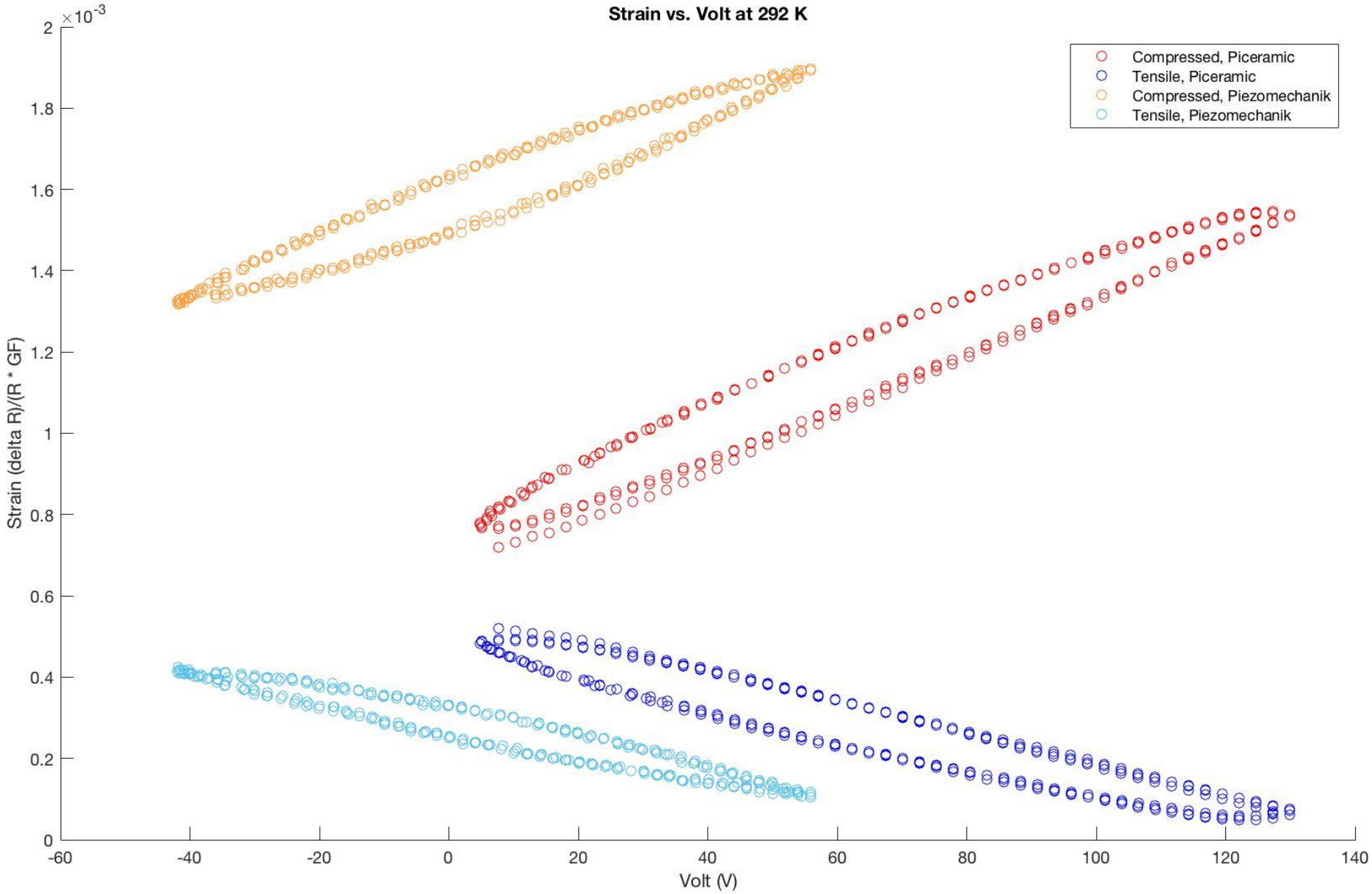
- Poisson Ratios are analyzed from 2 piezo-stacks
  - Piceramic (Jan. 2017) and Piezomechanik (Mar. 2017)
- Experiment starts at 300K
  - Goes down to 0K and back up at a regular temp. interval
  - System waits for about 200 seconds at each T (for equilibrium)
- Voltage is ramped through the piezo-stack
  - A hysteresis graph is obtained at each temperature
- Process repeats at the next temperature

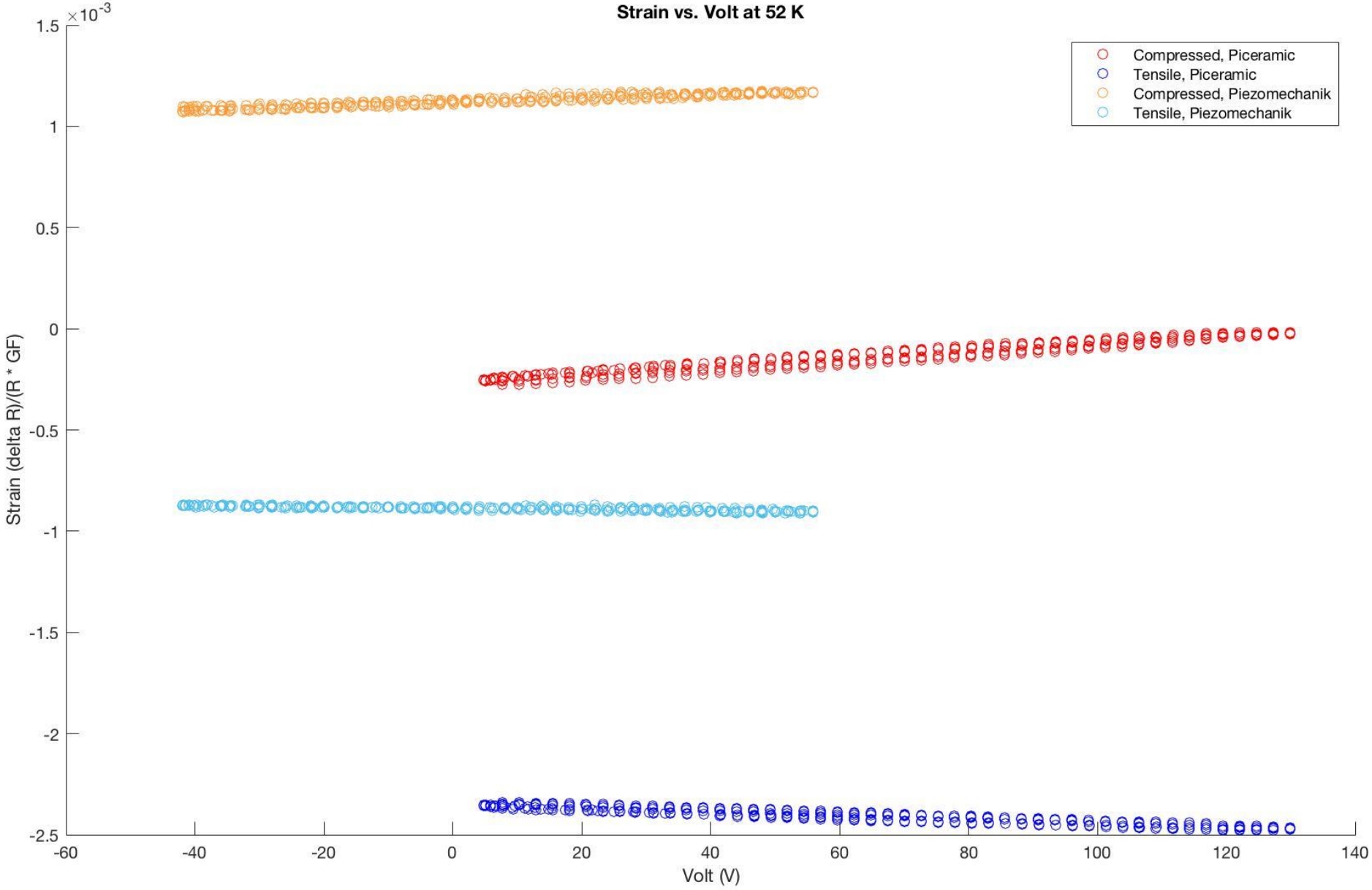
Measurement Procedure

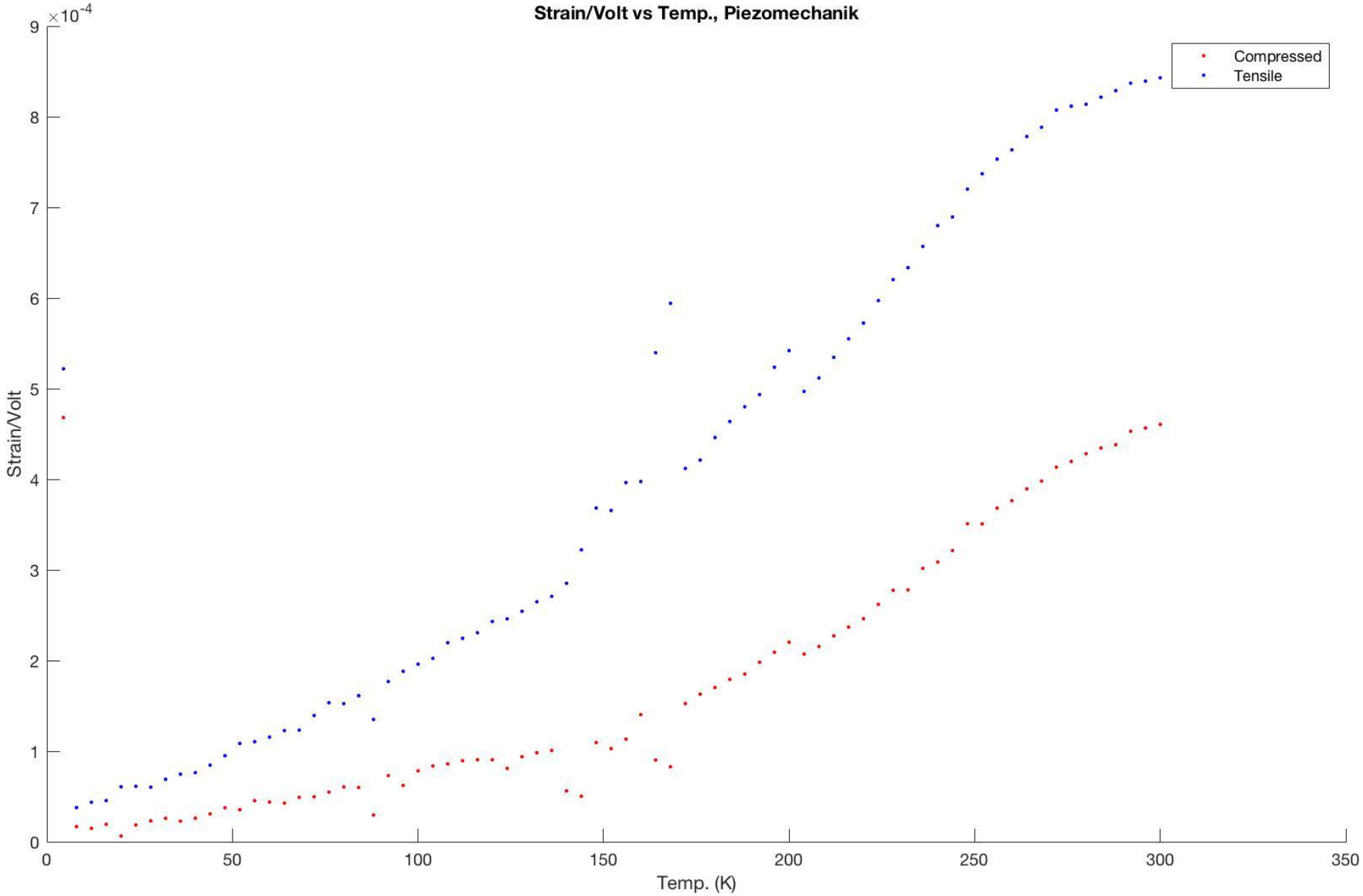
- Data analysis process:
  - Best fit of all hysteresis is done at each temperature range
    - To obtain the average strain/volt at each temperature range
  - The fitted strain/volt at each temperature is then plotted
    - Poisson ratio is calculated from each fitted data point

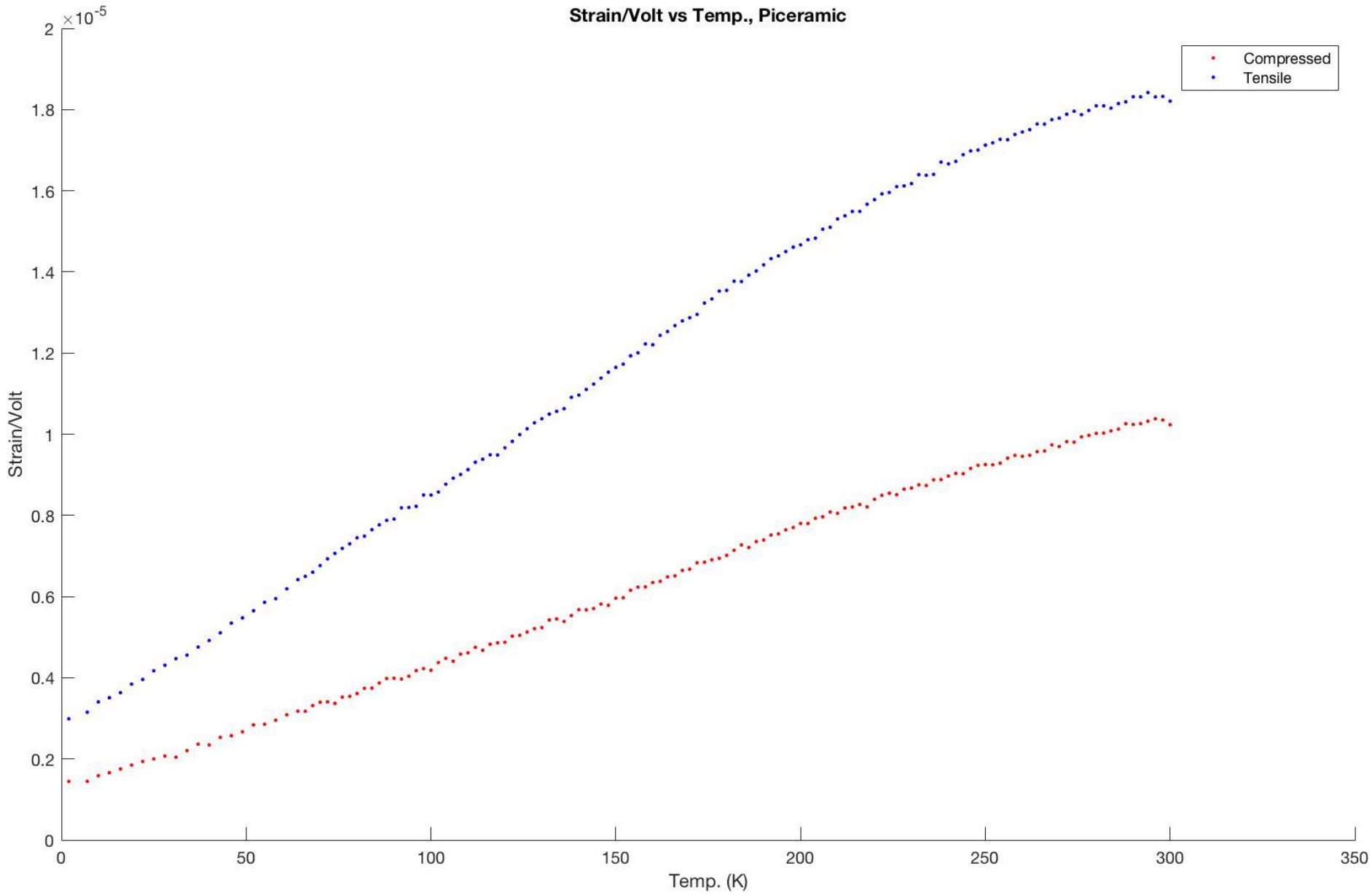
Results

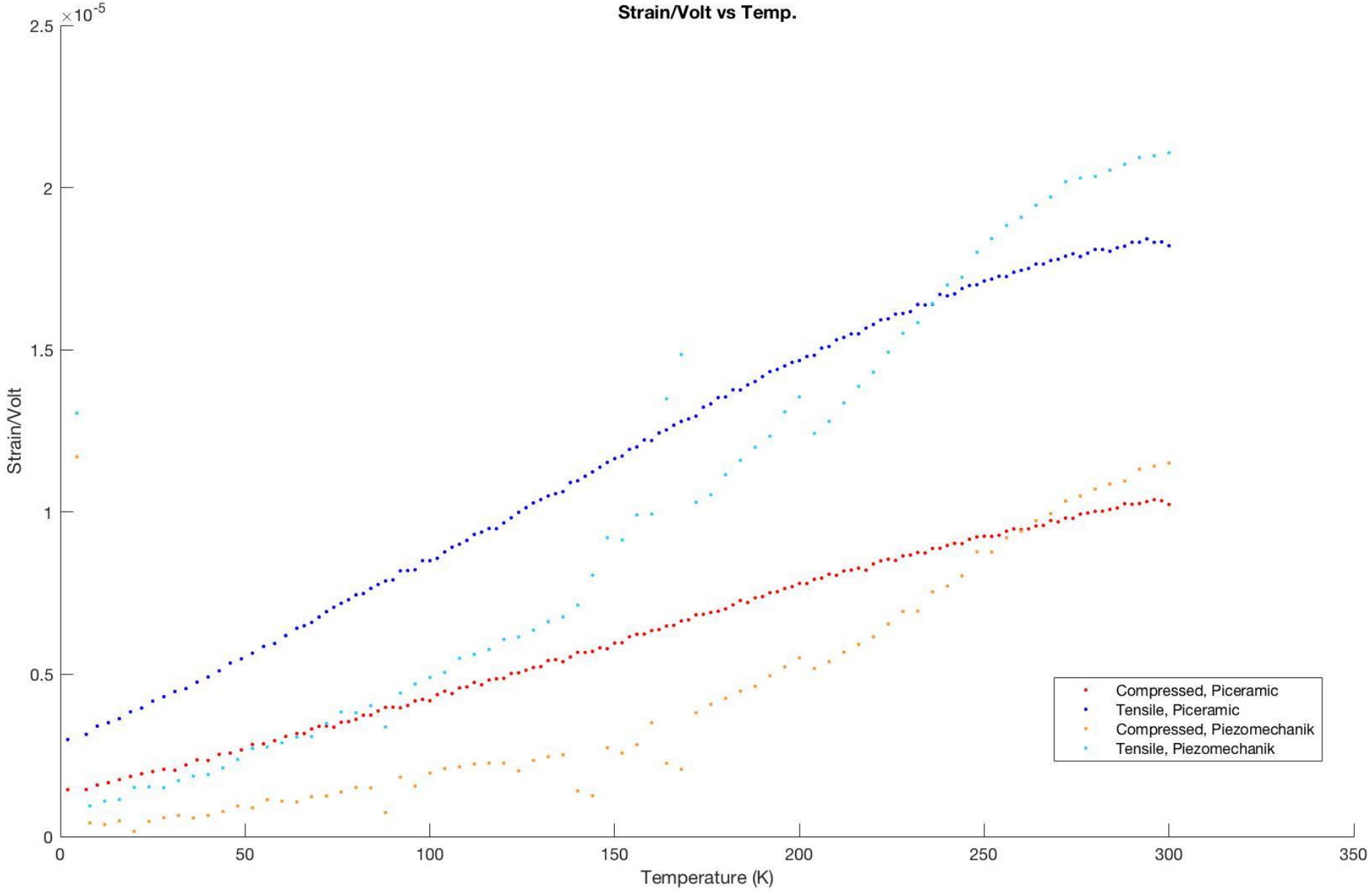

Strain vs. Volt at 272 K
Compressed, Piezomechanik
Tensile, Piezomechanik
×10^-3
2.5
2
1.5
1
0.5
0
Strain (delta R)/(R * GF)
-60
-40
-20
0
20
40
60
Volt (V)

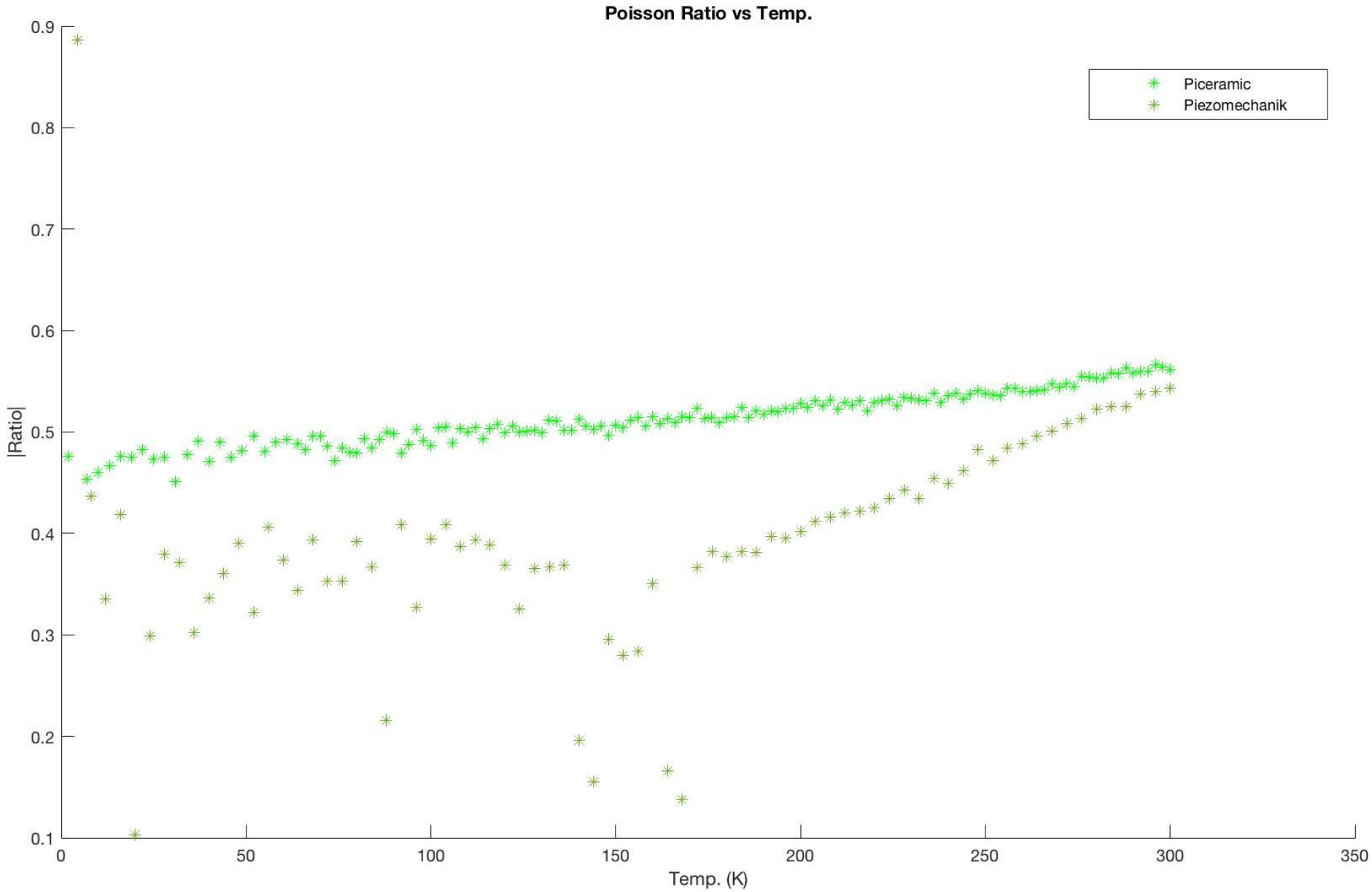

Strain vs. Volt at 292 K
×10^-3
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Strain (delta R)/(R * GF)
-60
-40
-20
0
20
40
60
80
100
120
140
Volt (V)
Compressed, Piceramic
Tensile, Piceramic
Compressed, Piezomechanik
Tensile, Piezomechanik


Strain vs. Volt at 52 K
×10^-3
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
Strain (delta R)/(R * GF)
-60
-40
-20
0
20
40
60
80
100
120
140
Volt (V)
Compressed, Piceramic
Tensile, Piceramic
Compressed, Piezomechanik
Tensile, Piezomechanik


Strain/Volt vs Temp., Piezomechanik
×10^-4
9
8
7
6
5
4
3
2
1
0
Strain/Volt
0
50
100
150
200
250
300
350
Temp. (K)
Compressed
Tensile


Strain/Volt vs Temp., Piceramic
×10^-5
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Strain/Volt
0
50
100
150
200
250
300
350
Temp. (K)
Compressed
Tensile


Strain/Volt vs Temp.
×10^-5
2.5
2
1.5
1
0.5
0
Strain/Volt
0
50
100
150
200
250
300
350
Temperature (K)
Compressed, Piceramic
Tensile, Piceramic
Compressed, Piezomechanik
Tensile, Piezomechanik


Poisson Ratio vs Temp.
Piceramic
Piezomechanik
|Ratio|
Temp. (K)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
50
100
150
200
250
300
350

Discussion

- New material (Piezomechanik) displayed poorer quality results
  - Than compared to one done in January (Piceramic)
- Potential reasons:
  - Small voltage range?
  - Not enough stycast?
  - Different material?

Thank you for listening!