How do we lay out a resistor?

We make resistors using **highres poly** layer. **Highres poly** is not a physical layer on the silicon wafer. So in the cross-section of a layout, you won’t find any **highres poly** layer. It is meant to mask parts of **poly2** or **electrode** that would remain high resistance. Usually in the absence of highres poly mask, poly2 or the electrode layer is bombarded with charged impurities to lower its resistance. The part of poly2 or the electrode layer that is masked by highres poly gets shielded and hence has a relatively high resistance.

With this idea, lets proceed to make a resistor of 10 kΩ.

The resistance per square of high-resistance poly2 in this process: $R = 1.24 \text{ kΩ per square}$

1) Calculate the number of squares we need:

   $R = \frac{L}{W} \cdot R$, we know $R = 10 \text{kΩ}$  $\Rightarrow \frac{L}{W} = 8 \text{(number of squares)}$

   Let us assume $W = 10\lambda = 3 \mu m$ (twice the minimum allowable width for electrode)

   $\Rightarrow L = 24 \mu m$

   Note: We can make the width smaller and hence the length would reduce. But similar to minimum width transistors, we wish to avoid minimum width resistors to achieve greater accuracy and matching performance in our resistors.

2) Draw a rectangle of **electrode (greenish yellow layer)** of 24 X 3 µm.

![Electrode Diagram](image1)

3) Draw a rectangle of **highres poly (blue fill layer)** of 25.2 x 4.2 µm such that each side of the highres poly overlaps the electrode layer by 0.6 µm.

![Highres Poly Diagram](image2)
4) Now, all that you need to add are the contacts that serve as the metal connection for the resistor. So extend the electrode layer beyond the highres poly layer such that the contact we place on the electrode layer is at least 0.6µm away from the highres poly edge. Overlap the contacts with metal. Your resistor is ready!

![Image of resistor design](image_url)

5) Now, after you DRC the file, extract it. It looks similar to this:

![Extracted resistor design](image_url)

Notice a device called res in a red box in the extract, which represents our resistor.
6) To check the value of this resistor that we have laid out, click on the `res` box and press `q` (properties). A window props up in which you select parameters to see the value of the extracted resistor.

Note: This value is close to 10 kΩ but not exactly 10 kΩ.
7) When we make really huge resistors, we often make it with a number of electrode sticks connected in a serpentine manner, the whole pattern covered by highres poly layer. This would help us make the resistor layout almost equally spaced in length and width, rather having a long layout.

For example, the following figure shows a 50kΩ resistor in a serpentine pattern rather having a long resistor of length = 120µm.