Energy Density between the Plates of a Parallel Plate Capacitor.

The energy stored in a capacitor is not localized on the charges or the plates but is distributed in the field. And as in case of a parallel plate capacitor field is only between the plates i.e. in a volume (A× d), the so called **energy density**.

Hence Energy density $= \frac{\text{Energy}}{\text{Volume}} = \frac{\frac{1}{2}CV^2}{Ad} = \frac{1}{2}\left[\frac{\varepsilon_0 A}{d}\right]\frac{V^2}{Ad} = \frac{1}{2}\varepsilon_0\left(\frac{V}{d}\right)^2 = \frac{1}{2}\varepsilon_0 E^2$.

Concepts

☞ In the expression of capacitance of parallel plate capacitor filled partially with dielectric term $\left(d - t + \frac{t}{K}\right)$ is known as effective air separation between the plates.

☞ When dielectric is partially filled between the plates of a parallel plate capacitor then its capacitance increases but potential difference decreases. To maintain the capacitance and potential difference of capacitor as before (i.e., $c = \frac{\varepsilon_0 A}{d}$, $V = \frac{\sigma}{\varepsilon_0}d$) separation between the plates has to be increased. Suppose separation is increased by d' so in this case $\frac{\varepsilon_0 A}{\left(d + d' - t + \frac{t}{K}\right)} = \frac{\varepsilon_0 A}{d}$ which gives us

$\boldsymbol{K = \frac{t}{t - d'}}$