Example 6.2

Calculate the threshold voltage of a silicon nMOS capacitor with a substrate doping $N_a = 10^{17}$ cm^{-3}, a 20 nm thick oxide ($\varepsilon_{ox} = 3.9\ \varepsilon_0$) and an aluminum gate ($\Phi_M = 4.1$ V). Assume there is no fixed charge in the oxide or at the oxide-silicon interface.

Solution

The threshold voltage equals:

$$V_T = V_{FB} + 2\phi_F + \frac{\sqrt{4\varepsilon_s q N_a \phi_F}}{C_{ox}}$$

$$= -0.93 + 2\times 0.42 + \frac{\sqrt{4\times 11.9\times 8.85\times 10^{-14}\times 1.6\times 10^{-19}\times 10^{17}\times 0.42}}{3.9\times 8.85\times 10^{-14}/20\times 10^{-7}}$$

$$= -0.09\ \text{V}$$

Where the flatband voltage was already calculated in example 6.1. The threshold voltage voltages for nMOS and pMOS capacitors with an aluminum or a poly-silicon gate are listed in the table below.

	Aluminum	p^+ poly	n^+ poly
nMOS	-0.09 V	0.98 V	-0.14 V
pMOS	-0.93 V	0.14 V	-0.98 V