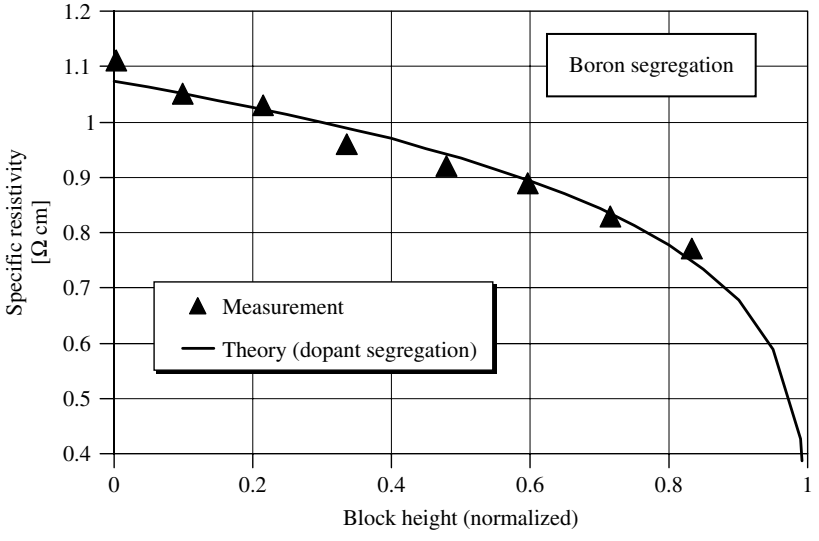

Figure 6.8 Decrease in the specific resistivity of *p*-type multicrystalline silicon due to segregation of the doping element boron

6.3.3 Crystal Defects

The main crystal defects in multicrystalline silicon are grain boundaries and dislocations. Concerning the attainable efficiencies of solar cells, not only the concentration of these defects but also their electrical activity is considered as crucial.

With respect to the grain boundaries and the grain size, basically smaller grains are observed at the beginning of the crystallisation process in the ingot bottom part. With increasing block height, individual grains prevail at the expense of surrounding grains and thus give rise to an increase in the mean grain size. This increase of grain size, however, depends on the crystallisation speed (see Figure 6.9). A higher crystallisation speed also means higher temperature gradients and thus an increased probability for the formation of crystal seeds in the melt that in turn lead to a limitation of the grain size. This is also the reason for faster crystallised block-cast material usually exhibiting smaller grains than conventional Bridgman-type multicrystalline silicon.

On the other hand, the grain sizes achieved with modern block-cast material are still large enough to not degrade solar cell efficiencies provided that the electrical activity of the grain boundaries is low enough. Grain boundaries and dislocations, if electrically charged, effectively attract minority charge carriers and consequently represent highly active recombination centres for photo-generated charge carriers. The electrical activity of grain boundaries and dislocations is determined by their impurity decoration (specifically by transition metals) and strongly increases with higher impurity concentrations.

Moreover, it was discovered that the shape of the crystallisation front during solidification also has considerable influence on the grain boundary activity [19]. Preserving a strictly planar solidification front clearly leads to a reduced grain boundary activity.