Extrinsic Semiconductor

Pure semiconductors have negligible conductivity at room temperature. To increase the conductivity of intrinsic semiconductor, some impurity is added. The resulting semiconductor is called impure or extrinsic semiconductor.

Impurities are added at the rate of ~ one atom per 10^6 to 10^{10} semiconductor atoms. The purpose of adding impurity is to increase either the number of free electrons or holes in a semiconductor.

Doping is a method of selectively increasing carrier concentration, by addition of selected impurities to an intrinsic semiconductor. This is called an extrinsic semiconductor. In any semiconductor at equilibrium, the law of mass action should be satisfied i.e.

$$np = n^2i \quad (1)$$

In an intrinsic semiconductor $n = p = ni$, so equation 1 becomes trivial. But when impurities are added to a semiconductor, to increase the carrier concentration, equation 1 restricts the increase to either electrons or holes. Both cannot be increased simultaneously. If n increases, then p decreases, and vice versa. Thus doping can selectively increase electron or hole concentration. An extrinsic semiconductor is formed by adding a small amount of impurities to a pure semiconductor crystal to preferentially increase carrier concentration of one polarity. There are two important terms in this definition

1. 'Small' - the concentration of impurities is very small, of the order of ppm (parts per million) or ppb (parts per billion).

2. 'Impurities' - these are precisely controlled additions to a pure material.
Not impurities in the sense of unwanted material. Dopants would be a better term for these additions.