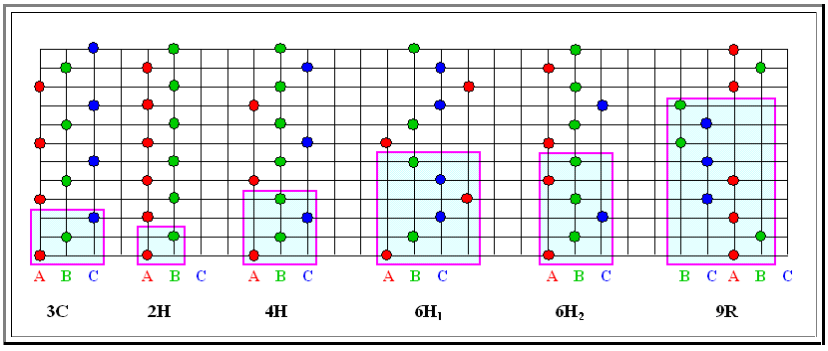
# Ramsdell Notation for SiC Polytypes

- The **Ramsdell notation** for the stacking of hexagonal layers of atoms is simple (and not always extremely useful):
  - Specify the total number of layers contained in a (possibly large hexagonal) unit cell and then add the letter **H**, **C** or **R**) to denote the over-all lattice type as being hexagonal , cubic, or rhombohedral , respectively.
  - The most simple variants are thus
    - **2H** for the hexagonal close packing, i.e. for a **ABABA....** sequence in the "**ABC**" notation familiar from Matwiss I for the ***hcp*** Bravais lattice
    - **3C** for the cubic close packing, i.e. the **ABCABCA....** sequence of the **fcc** Bravais lattice.
- The designation "**6H-SiC** " thus means that we have **6** layers in some stacking sequence that follows the basic rules (no "head-on-head" configuration; **B** or **C** after **A**; **A** or **C** after **B**, ...) and produces an unit cell that is hexagonal.. Let's look at examples to get the idea:




  - Now you have problems:
- **1.** There might be more than on way to stack, e.g., **6** planes with a hexagonal unit cell. The designation **6H** thus may not be unique.
  - This is indeed the case as shown above. Subdivisions are needed; we have, e.g., the **$6H_1$** and **$6H_2$** configuration. Just how many possible subdivision are possible is not easily seen, however.
  - Note: While all "legal" stackings of **6** planes produce a unit cell of the hexagonal type, it is not necessarily the *smallest* Bravais lattice of the structure, not to mention the smallest unit cell! Looking at smallest unit cells, you might rather end up with a cubic or rhombohedral lattice. For the **3C** structure this is sufficiently clear, for the others you have to believe it (or to sit down and do serious crystallography). This leads directly to the second question:
- **2.** It is easy, of course, to generate all kinds of allowed stacking sequences for a given number; say **9**. Repeating the sequence will produce a crystal with some Bravais lattice. But is it possible to have all kinds of combinations? What is possible? Is there besides a **9H** also a **9C**, and/or a **9R** configuration? Could other Bravais lattices come up?
  - Who knows. What kind of lattice you get, e.g., is not directly obvious from the picture above (at least not to me). There will be restrictions, of course; e.g. since the **Si**- and **C**-Atoms must always be tetrahedrally coordinated in any allowed stacking sequence. It appears that you always have only cubic, hexagonal and rhombohedral Bravais lattices to deal with.
  - So we will let the matter rest, assuming that crystallographers have figured it out and that, if necessary, the questions above can be answered unambiguously.
- There are many more polytypes besides the ones shown in the picture. A more common one is actually **15R** (stacking sequence **ABCBACABACBCACB**).
  - Most stable is, perhaps, the **3C** structure (also known as **β-SiC**) at lower temperatures, and the **6H** modification (**α-SiC**) above about **1800 $^0$C**. In other words, we have a phase transformation upon crossing a certain temperature.
  - But there are many more variants; the list goes up to **39H**, **39R**, **45R** and **51R**.
- This brings up an obvious and difficult question:
  - How, for an extreme example, a growing **51R** crystal "knows" what has happened **51** stacking planes below, when it adds another layer, is still a kind of mystery. The crystal must "know" somehow, otherwise it could not do the proper stacking - think about it.
  - Considering that we usually may safely neglect interactions between second-nearest neighbors in a lattice, this is a tough nut to crack, indeed!