SDMA

Space division multiple access (SDMA) is a simple brute force method of multiplexing. SDMA is used when you have different users on different fibers and information needs to be sent from a user on one fiber to a user on another. The simplest form of SDMA is when having N users means there are N channels, N fibers, and up to N^2 nodes. The nodes are where the actual switching between the two fibers takes place. In a typical crossbar configuration with four inputs and four outputs, there are 16 nodes which can direct any input to any output. In this configuration, each communication uses a dedicated physical path.

As fiber comes closer to the home, the need for switching between purely optical paths becomes more important. SDMA is the way to achieve this. SDMA is a fairly mature technology and therefore available today. Switching is done nowadays with optoelectronic switches. SDMA can also be used in conjunction with WDM and TDM. SDMA technology is used to complement WDM and TDM and is not something to take their place. When a WDM or TDM signal is sent into a SDMA switch matrix, the same signal will come out.

The most basic space switching element is the directional coupler. The directional coupler is used as a basic 2x2 crossbar switch. A crossbar switch has two different states it can be in, the bar state and the cross state. The bar state is when input 1 is routed to output 1 and input 2 is routed to output 2. The cross state is when input 1 is routed to output 2 and input 2 is routed to output 2. A 2x2 directional coupler can be used as a building block for larger switch matrices. 16 of them can be used to make a 4x4 switch.

Directional couplers have sub-microsecond reconfiguration times and they have a fabrication limited size. Currently, 16x16 is the largest matrix that can be fabricated onto a single chip using directional couplers as the switching element. The bending radii needed for the waveguides is one of the factors limiting the number of channels on a substrate. Crosstalk and insertion loss are the real factors behind achievable matrix switch dimensions though.

For increasing matrix switch dimensions, better individual coupler crosstalk and insertion loss performances are needed. In order to keep the total matrix crosstalk ratio the same, as switch dimension increases each single switch crosstalk must become better. The same is true for insertion loss.

There are many different types of network architectures that can be used to create an SDMA switch besides a crossbar configuration which uses N^2 switches. One example
is the Banyan switching system. It has a lower switch count at $N(\log_2 N + 1)$ switches and is rearrangeably nonblocking meaning some inputs and outputs might have to be rearranged to switch another input to another output. As usual, crosstalk and insertion loss of the individual switches are the driving factors behind achievable switch dimensions.

A different kind of space switching element is the spatial light modulator. This device changes the polarization of the light passing through it and is controlled electronically. They normally have millisecond to microsecond switching speed. A switch can be made using a linear or two-dimensional array of liquid crystal spatial light modulators.

Some of the advantages of SDMA are the fact that it can be a purely optical signal path and therefore is capable of terabit per second throughput once the connection has been made. It is also transparent to the system if its purely optical. You can use any bandwidth or data rate achievable in fiber.

Some of the disadvantages of SDMA is the fact that the number of switches in your matrix can increase by $N^2$ when adding new inputs and outputs. There are also high insertion losses since each input must have the capability to be split to any output. It is also not easy to add additional inputs and outputs, the whole switch must be replaced.